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A DATABASE PROCESSING APPLICATION
FOR THE
DIRECT AIR SUPPORT CENTER

by

Curtis S. Ames

December, 1991

Thesis Advisor:

Daniel R. Dolk

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A Database Processing Application
for the Direct Air Support Center

by

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Captain, United States Marine Corps
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Submitted in partial fulfillment
of the requirements for the degree of

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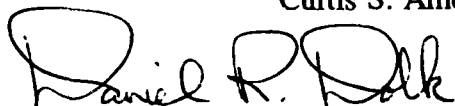
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ABSTRACT

The Marine Air Command and Control System execution of Direct Air Support is based on the concept of centralized command and decentralized control. It is completed manually using standardized procedures and controls to ensure responsiveness in highly dynamic situations. This thesis investigates the issues in developing and implementing an automated database application for receiving, processing, disseminating, and recording information as it pertains to the Air Tasking Order within the Direct Air Support Center. A relational database design is proposed using Entity-Relationship modeling. A simple prototype of the system is implemented in dBASE IV to demonstrate proof of concept. The major benefit of the database approach is that databases are dynamic and can evolve with changing needs.



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I. INTRODUCTION

A. BACKGROUND

Information has always been the most important resource in command and control decisions. Unfortunately, communication has been viewed as a distant relative of the military profession. It is only in the last couple of decades that information systems to support the command, control and communication processes have been recognized in their own right by the military. Technological advances in the development of digital techniques for the representation and processing of information, and microelectronics have led to the fulfillment of long existing information requirements. Automated communications and information systems have enabled decision makers to cope effectively with the complexity of command and control on the battlefield.

The Marine Air Command and Control System (MACCS) execution of Direct Air Support is based on the concept of centralized command and decentralized control. It is completed manually using standardized procedures and controls to ensure responsiveness in a highly dynamic situation. Based on the information contained in the Draft Operational Requirements Document (ORD) for the Direct Air Support Central, Marine Corps Combat Development Command identified operational deficiencies in the data processing capabilities of the Direct Air Support Center (DASC). The DASC requires an automated message and information handling capability to exchange, store, display, and

manipulate digital information using established Marine Tactical Systems and Message Text Format (MTS/MTF) standards.

This thesis investigates the issues in developing and implementing a database processing system for receiving, processing, disseminating, and recording information required by the DASC as it pertains to the Air Tasking Order (ATO). Background of the MACCS, DASC functions, the ATO cycle, and lessons learned from Operation Desert Storm are discussed. Application of an integrated Database Management System (DBMS) within the DASC will be explored addressing system and joint inter-operability requirements/problems. Man-machine interface will be stressed in the DBMS. The potential use of this system will be researched to improve the efficiency and effectiveness of information flow and decision making within the DASC, the MACCS, and the Fire Support Coordination Center (FSCC).

B. SCOPE

The focus of this thesis is a system requirements review of an integrated DBMS for the receiving, processing, disseminating, and recording of the ATO in the DASC. Research is specifically intended to model a system that uses available data in standardized format to build a database, query the database, and then utilize the information to: (1) provide information to decision makers, (2) disseminate information to those who require it, (3) add and subtract information within the database. Research will cover database architecture in an integrated DBMS to include consideration in man-machine interface.

C. THESIS OBJECTIVES

The primary objective of the thesis is to identify the system and information requirements for a database processing application that automates the ATO functions within the DASC. This will entail the following steps:

1. Determine the feasibility of automating the ATO functions within the DASC.
2. Demonstrate the potential to improve information flow and decision making within the DASC.
3. Highlight problem areas in developing and implementing a DBMS for use in the DASC.
4. Translate the user defined data requirements into a conceptual model, and design and build a database using that model.

D. RESEARCH QUESTIONS

There are several approaches to implement a database processing application. The primary research question is to determine the information requirements for a database application and generate a database design that fulfills the determined requirements. In support of the primary question, the thesis will identify the system requirements of an automated database and the design issues to be addressed in modeling the proposed system.

E. LITERATURE REVIEW AND METHODOLOGY

Background knowledge on the subject area was obtained through research into technical reports, academic publications, and a course on relational databases. The doctrinal and operational knowledge was gained from doctrinal publications, technical

reports, DASC project documentation, and interviews with Marines in the air support control community.

The methodology used in this thesis generally follows the application development process outlined by Kroenke and Dolan (1988, p. 75-82) which consists of five phases:

1. The definition phase attempts to define the scope of the project.
2. The requirements phase determines as specifically as possible what the new system must do.
3. The evaluation phase studies alternative solutions to the requirements.
4. The design phase involves creating the logical structure of the database.
5. The implementation phase constructs the system according to the design.

The scope of this thesis, as defined earlier, will look at the user requirements of a database processing system and model a database based on those requirements. The thesis will emphasize the design phase of the database based upon user defined requirements. Alternative database models will be addressed, and implementation of the design will be demonstrated on a specific microcomputer DBMS.

F. SUMMARY OF FINDINGS

The intent of relational database design is to increase the accessibility of database information to all users, minimize redundancy, and allow for implementation of future applications to the DBMS. DBMS capabilities include mechanisms for displaying data through report generators and responding to "ad hoc" database queries. The relational model allows data independence, meaning that applications maintain more flexibility for

changes in the future than traditional file processing approaches. The database design developed by the entity-relationship approach is independent of and not restricted by the capabilities of any specific database system. It can be implemented in any relational DBMS environment. These concepts are important in the rapidly changing command and control environment. As users see how automation benefit decision making, their "need" for additional data and information processing will grow.

G. ORGANIZATION OF THE STUDY

The remainder of the thesis is organized as follows:

- Chapter II provides the background to the MACCS to include the DASC functions and the ATO process. It lays the groundwork for demonstrating how a DBMS could improve the efficiency and effectiveness of decision making and information flow within the DASC.
- Chapter III explores the technology, man-machine interface, and system requirements of an automated information system, and identifies the information flow requirements within the DASC.
- Chapter IV explores database processing concepts to include design, tools, and techniques.
- Chapter V presents a database design and implementation for the DASC application.
- Chapter VI summarizes the benefits of a database processing approach for the DASC application.

II. MARINE AIR COMMAND AND CONTROL OPERATIONS

A. GENERAL

This chapter presents the fundamentals of control of aircraft and missiles, the MACCS, the DASC, the ATO cycle, and lessons learned from Operation Desert Storm/Shield. The objective is to document the existing MACCS operational environment and eventually to identify the information flow requirements of the DASC with respect to the ATO. These requirements will be specified in Chapter III and serve as the basis for constructing a database application based on the model discussed in Chapter IV.

B. CONTROL OF AIRCRAFT AND MISSILES

The capability to conduct successful tactical air operations is essential to the execution of military operations. The Marine Corps has organized an aviation combat arms capable of meeting the requirements of a flexible, responsive aviation combat element specifically tailored to meet the anticipated tactical situation. When combined with the requisite ground elements, the result is a balanced, self-sufficient, cohesive organization composed of air and ground arms known as the Marine Air-Ground Task Force (MAGTF).

A task organized Aviation Combat Element (ACE) will normally be formed to fully support the MAGTF. The ACE supports the MAGTF with firepower and mobility it would not have otherwise. The ACE is not a permanent organization, but is organized

and equipped to provide the aviation functions required to accomplish the assigned mission. The tasks required to support the ACE's mission fall into six functional categories: offensive air support, anti-air warfare, assault support, air reconnaissance, electronic warfare, and control of aircraft and missiles.

Control of aircraft and missiles is defined as "the coordinated employment of facilities, equipment, communications, procedures, and personnel which allow the MAGTF commander to plan, direct, and control the efforts of the ACE to support the accomplishment of the MAGTF's mission." (FMFM 5-60, 1990, p. 1-1-2) According to JCS Pub 1, command and control is "the exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of his mission." (JCS Pub 1, 1 April 1989, p. 76) Command includes "...the authority and responsibility for effectively employing available resources...for the accomplishment of assigned missions." (JCS Pub 1, 1 April 1989, p. 76) Control is defined as the "authority which may be less than full exercised by a commander over part of the activities of subordinate or other organizations." (JCS Pub 1, 1 April 1989, p. 87) Therefore "control of aircraft and missiles" is synonymous with "authority over aircraft and missiles."

C. MARINE AIR COMMAND AND CONTROL SYSTEM

The ACE commander exercises operational control over his assigned forces through the MACCS. The MACCS is an integral part of the ACE's organizational structure and consists of units specifically equipped with personnel, facilities, communications, and trained in procedures to support the command and control of all MAGTF air operations.

The MACCS operates under the principle of centralized command and decentralized control for maximum responsiveness to combat operations.

The personnel and equipment required to establish the MACCS are contained primarily in the Marine Air Control Group (MACG) and its subordinate squadrons. The functional components (personnel and equipment) of the MACCS depicted in Figure 1 include:

- Tactical Air Command Center (TACC) is the senior MAGTF air command and control agency which serves as the operational command post of the tactical air commander (TAC), usually the ACE commander. The TAC and his staff execute the current air battle and plan for the future battle culminating in the publication of the Air Tasking Order (ATO) and appropriate fragmentation (FRAG) orders.
- Sector Antiair Warfare Coordinator's (SAAWC's) facility, which is normally colocated with the Tactical Air Operations Center (TAOC), is the senior air defense battle manager for the ACE. It provides the interface between the TAOC and TACC.
- TAOC and Early Warning/Control (EW/C) sites detect, identify, and control the intercept of hostile aircraft and missiles.
- Direct Air Support Center (DASC) processes immediate air support requests, coordinates aircraft employment with other supporting arms, and controls aircraft transmitting its area of responsibility. A complete description of the DASC's roles, tasks, inter-agency relationships and information needs will be discussed later.
- Air Support Radar Team (ASRT) provides day/night all-weather control of aircraft operating in support of MAGTF operations.
- Subordinate Command Posts (CPs)/Combat Operation Centers (COCs) provide the primary control agency from which Light Antiaircraft Missile (LAAM) and Low-altitude Air Defense (LAAD) Battalions can direct and control the HAWK and Stinger missile systems.
- Marine Air Traffic Control Squadron (MATCS) Detachment provide continuous all-weather air traffic services for expeditionary airfields and remote landing sites.

- Airborne Control Agencies offer flexibility to operate either as an extension of the means of control to functional control agencies (Tactical Air Coordinator (Airborne) (TAC(A)), Helicopter Coordinator (Airborne) (HC(A))), in support of specific ground units (Forward Air Controller (Airborne) (FAC(A))), or in coordination of other aircraft (Refueling Area Coordinator (RAC)).
- Tactical Air Control Parties (TACPs) are organic to the Ground Combat Element and provide air liaison to land forces and terminal control of aircraft.

MACCS agencies have no control over aircraft or other units unless specifically delegated to them by the appropriate commander. Types of control that are usually delegated include:

- Command. The TACC is the one MACCS agency that exercises command.
- Air Direction. The authority to regulate the employment of air assets.
- Air Control. The authority to direct the physical maneuver of air assets.
- Airspace Control. The coordination, integration and regulation of airspace.
- Terminal Control. A subset of control that applies to the delivery of ordnance, cargo, or personnel by aircraft.

The MACCS will be tasked-organized to provide MAGTF commanders with the assets required for effective command, coordination, and control of all MAGTF air operations. Interagency relationships between the MACCS elements can be defined as the type of control each agency exercises. Development of the ATO is a form of air direction that the ACE commander exercises through the TACC. Air control can be thought of as an instruction given to a pilot by a control agency to alter his course. Airspace control is the authority to direct aircraft so the best use is made of a defined area of responsibility. The DASC exercises both air control and airspace control when authority has been delegated to them. The DASC will receive air direction via the ATO

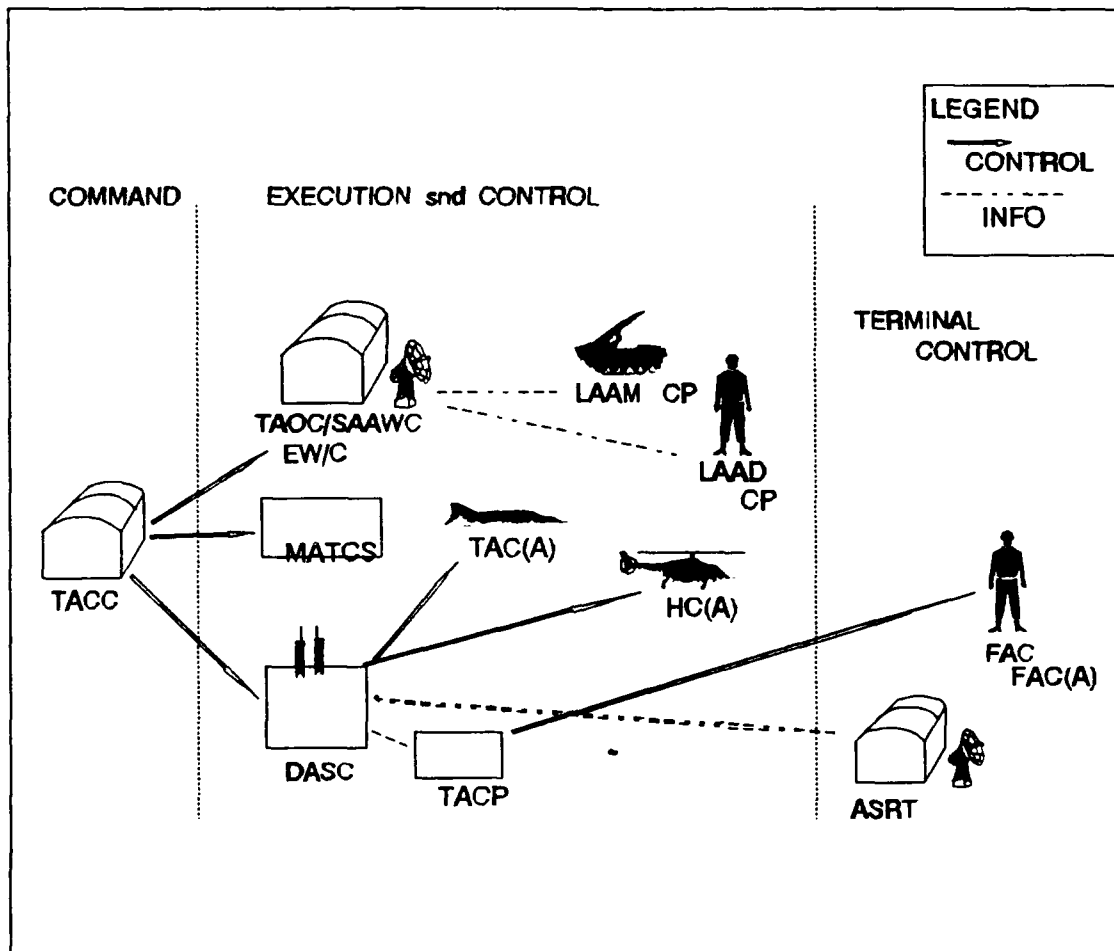


Figure 1. MACCS Agencies and Control Authority

from the TACC. Figure 1 depicts the MACCS and its control relationships with the various agencies.

D. DIRECT AIR SUPPORT CENTER

1. Background

The Direct Air Support Center is the principle air control agency responsible for the direction of air operations directly supporting ground forces. The DASC processes direct air support requests, controls aircraft in its area of responsibility, manages terminal

control agencies in support of the ground combat element (GCE), and coordinates air missions requiring integration with other supporting arms.

The DASC functions in a decentralized mode of operation under the command of the TACC. It is normally the first major air control agency ashore and normally lands with the senior Fire Support Coordination Center (FSCC) during scheduled or on-call waves. It physically or electronically colocates with the senior FSCC and works closely with this agency to ensure the coordination of air support with other supporting arms. The DASC maintains the capability to operate during mobile combat situations by displacing by echelon to preserve operational continuity. The "echelon DASC" will have the capability to perform the same tasks as the main DASC.

Functional positions within the DASC include directors and net operators. Directors interface with, and control aircraft. Net operator coordinate with agencies external to the DASC. The functions and tasks performed by the directors and net operators within the DASC is discussed next.

2. Tasks

The DASC provides direct air support functions for the MAGTF by performing the following tasks:

- To receive fragmentary operation orders (FRAGOs) and ATOs from the TACC and coordinate preplanned scheduled direct air support. The ATO and FRAGOs are normally received on a daily basis but may be modified as changes occur. Information about these changes will normally come via the TACC.
- To receive, process, and coordinates requests for immediate or on-call air support. These requests will normally originate from the supported ground combat element requesting tactical air, assault support, or medical evacuation. This is one of the most critical tasks performed by the DASC.

- To adjust preplanned scheduled aircraft and divert airborne assets based upon mission priority in coordination with the senior FSCC when delegated authority by the TAC.
- To provide coordination in the execution of direct air support missions with other supporting arms through the appropriate FSCC.
- To coordinate subordinate terminal control agencies as required.
- To receive and disseminate pertinent tactical information reported by aircraft performing direct air support missions.
- To provide aircraft and other air control agencies with advisory information for the safe conduct of flight.
- To monitor, record, and display information on direct air support missions.
- To maintain friendly and enemy ground situation displays, as necessary, to coordinate direct air support missions.
- To provide information to other MACCS agencies concerning the friendly and enemy situation to include aircraft position.
- To refer unresolved conflicts in supporting arms to the fire support coordinator and provide an operational point of contact to ensure air support is responsive to the tactical situation.

3. Communication Links

In order for the DASC to perform these tasks, rapid and reliable communication links must be maintained with agencies external to the DASC. The command and control connectivity between the DASC, the aircraft and these external agencies is accomplished by radio. The primary DASC interagency relationships depicted in Figure 2 include:

- **DASC/TACC.** The DASC is subordinate to the TACC and provides for decentralized control of direct air support missions including close air support (CAS), and assault support. The TAC will ideally delegate divert and on-call launch authority of aircraft to the DASC to ensure minimum response times to

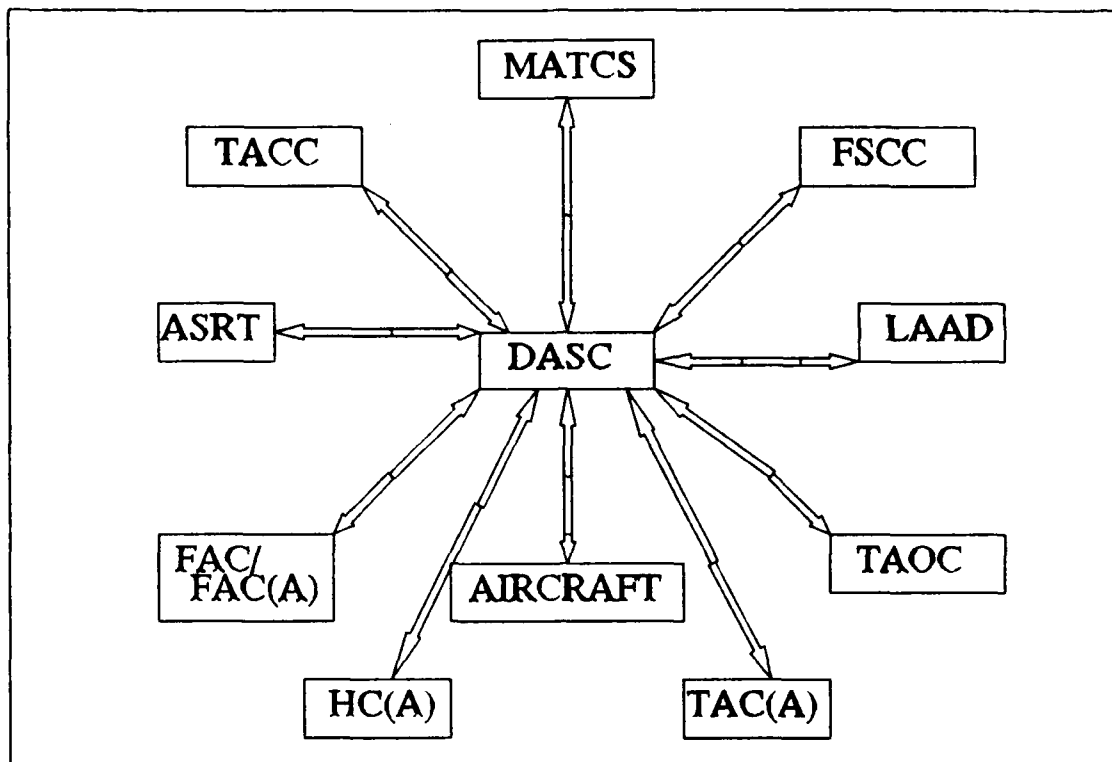


Figure 2. DASC Interfaces

MAGTF requirements. The TACC provides the DASC with appropriate ATOs, FRAGOs, aircraft call-signs, and aircraft availability. The DASC and the TACC exchange tactical information, intelligence, and the progress and effectiveness of direct air support missions.

- **DASC/FSCC.** Since the FSCC is the final arbitrator for all supporting arm conflicts the DASC and FSCC maintain close ties. The DASC and FSCC must be able to exchange timely information on tactical information (fire support coordination measures, friendly/ enemy unit positions, etc.), pertinent intelligence data, status of immediate air support requests, bomb damage assessments, divert and on-call launch decisions, and other prearranged data items.
- **DASC/Antiair Warfare (AAW) Agencies.** The DASC must be able to exchange tactical data information and pertinent friendly aircraft location with the appropriate AAW agencies (TAOC, LAAD/LAAM CPs).
- **DASC/Airborne Controllers.** The DASC must coordinate and exchange information with airborne control agencies pertaining to their responsibilities.

- DASC/ASRT. The ASRT is a terminal control agency subordinate to the DASC and receives all tactical data information from the DASC.
- DASC/TACPs. The DASC receives and processes immediate air support requests from the terminal controllers (Forward Air Controllers (FACs)) and apprises the TACPs and FACs of their status.
- DASC/OTHERS. The DASC will establish and maintain communication links with other agencies as required. Examples of this include, MATCS, Remotely Piloted Vehicle (RPV) Receiving Station, and the Air Force Air Support Operations Center (ASOC).

4. Current Operations

The DASC is a flexible, communications intensive facility that may be configured to support a variety of tactical situations. It is presently a manual system using procedural control methods and voice communication to fulfill its tasks.

The ATO is issued by the TACC and distributed to the MACCS elements on a daily basis. This ATO may or may not be a re-creation of the Air Force ATO. The means of distribution of the ATO may be via message traffic through a message center, courier, or local area network. Considerable time is then expended in processing and disseminating the ATO data within the DASC and retransmitting applicable ATO mission data to the ASRT or TACP's. The DASC receives voice or message traffic whenever a change to the ATO occurs.

Requests for immediate air support are transmitted from the TACPs to the DASC over the voice only Tactical Air Request (TAR) Net. All FSCCs monitor the TAR net and may disapprove, or by their silence, give consent to, the immediate air request (Figure 3). Upon receipt, the DASC will concurrently process the request, and coordinate mission planning with the colocated FSCC. The DASC will fulfill the request by

diverting lower priority airborne aircraft or by launching on-call missions. Each request requires manual completion of a specific form, must be posted on display boards, and transmitted to the TACC. Upon completion of the request, mission data is manually recorded on the form and disseminated to the TACC and FSCC.

As all types of operational message traffic increases, the DASC's operational mission data becomes less current because of the workload in manual processing, dissemination, transmission and posting of information.

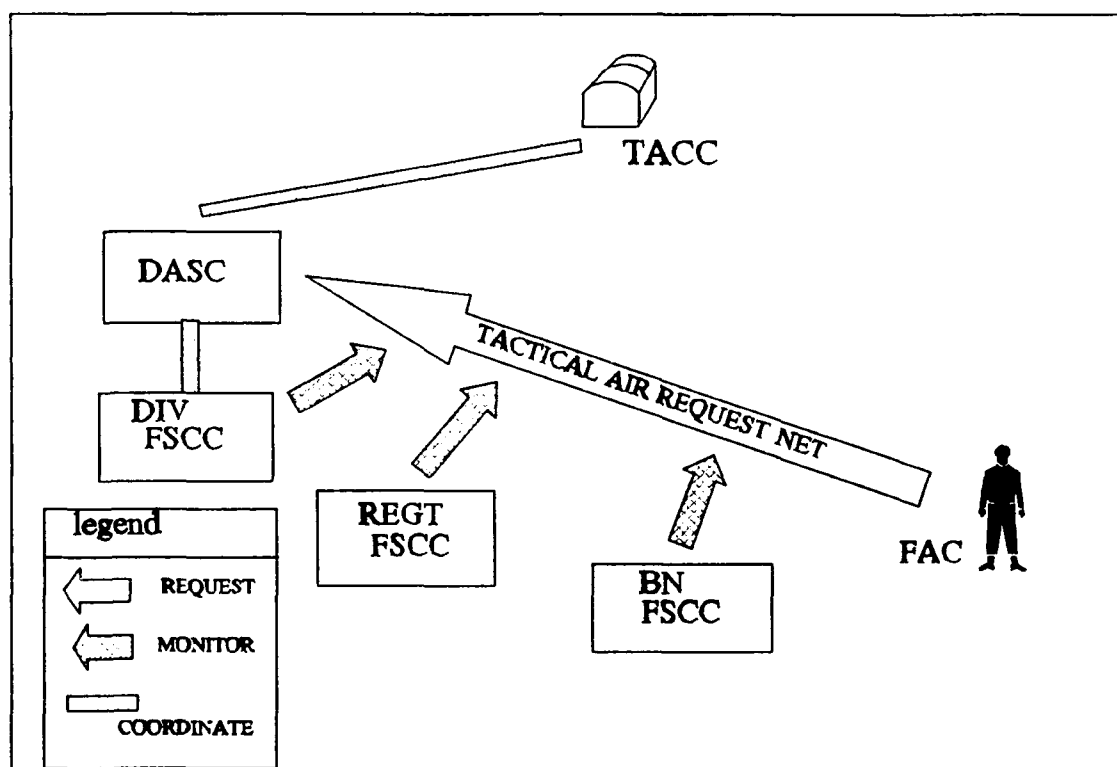


Figure 3. Immediate Air Requests

E. AIR TASKING ORDER

The ATO planning process for tactical air operations is a continuous activity that begins at the senior MAGTF level for the Marine Corps or the joint force theater level

in combined operations. The planning steps will be treated generically, using the Marine Corps as an example (Figure 4). The time sequence, usually 36 hours for the Marine Corps, would be longer when considering the joint level. The planning sequence provides background on how the ATO is generated and transmitted by the TACC and received and processed by the DASC.

The MAGTF commander develops the strategy and establishes the objectives for the conduct of military operations and apportions the available force to the various air tasks for a specific period of time. Apportionment is usually expressed as a percentage of total available assets assigned to the various missions (CAS, AAW, etc.) or in terms of priority by mission or geographic area. This apportionment guidance is based on the recommendation from his component commanders (ACE, GCE, etc.) and is promulgated in the apportionment guidance.

The ACE commander reviews his assets and allocates them in terms of sorties according to actual number of aircraft by type for each mission category consistent with the apportionment guidance. The future battle cell (FBC) in the TACC is responsible for developing the detailed plans of the ATO based on the apportionment and allocation of resources. The ground combat element provides the FBC with a prioritized target list for air interdiction targets and any additional preplanned requests to include a needed preplanned/immediate missions mix. The FBC considers the weather, enemy threat, availability of assigned forces and weapons, and target selection when developing the plan. Sorties in excess of MAGTF direct support requirements will be provided to the

Joint Force Commander for joint force tasking. The results of this planning process are disseminated as the ATO.

Although there is no specific format for the ATO, the ATO provides the mission details, special instructions, general information and remarks required by the subordinate units to execute their assigned tasks. The ATO will normally be transmitted in message text format (USMTF) or marine tactical standard (MTS). The USMTF ATO message is further discussed Chapter III and is listed in Appendix C.

Upon receipt of the ATO, aircraft groups generate FRAGOs assigning specific missions to squadrons and aircrews. Control agencies review, manipulate, and manually record the ATO onto report in/out (RIO) forms/logs and time-lines in preparation of controlling and directing the aircraft.

F. LESSONS LEARNED FROM OPERATION DESERT STORM

The IDASC (Improved DASC) Users Conference was held 8-12 April, 1991 at Mare Island, California following Operation Desert Storm primarily to "get a consensus of the air support control community on the priority and nature of proposed requirements (IDASC project)." (Report of Travel/Conference, 1 May 1991, p. 1) Receipt of the ATO was a main discussion item of the air support control community at this conference as the following item reflects:

- "SUBJECT: RECEIPT OF THE ATO
- DISCUSSION: The Joint ATO, issued by the Air Force was upwards of 700 pages long and originally was received via the Division Communications Center. Later,

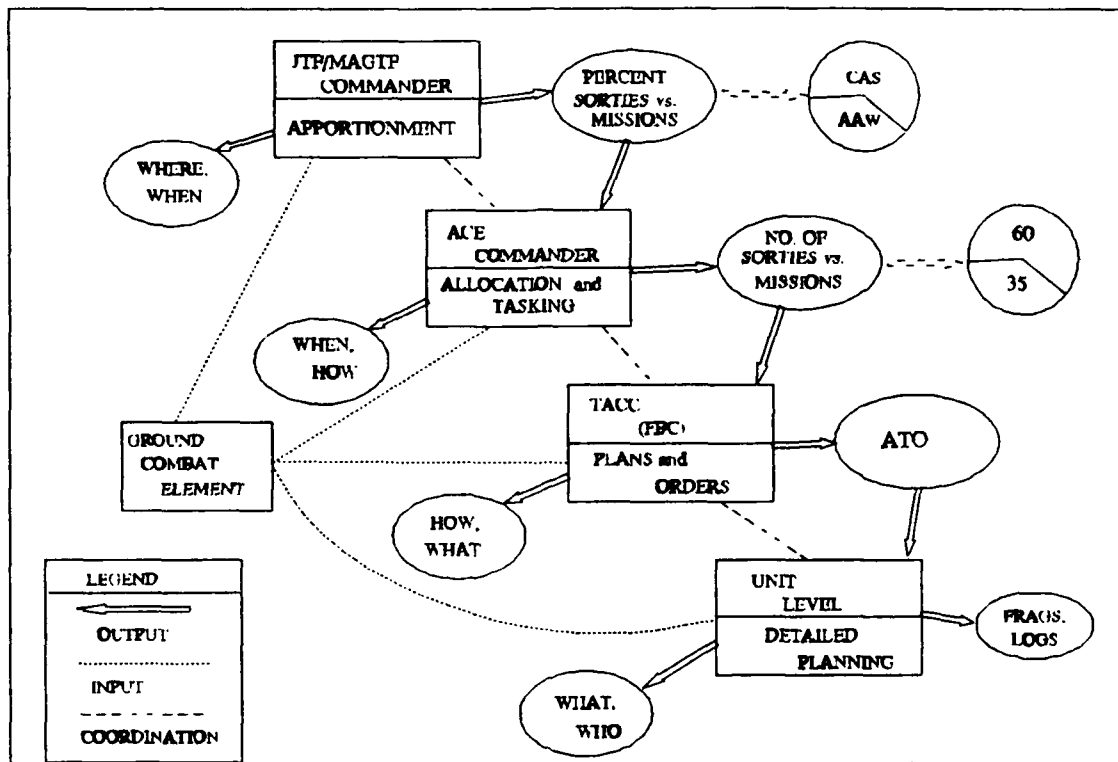


Figure 4. ATO Planning Process

it was scrubbed by the TACC and sent to the DASC via LAN. Received by the DASC on a UYQ-85, it arrived as two documents, a fixed wing and helicopter ATO. The scrubbed version, however, did not include other services aircraft. While the large joint version was still available via the communications center, significant effort was necessary to glean out the applicable missions from this unabridged version. While a standard MTF format was used, some Marines stated that some standardization still needed to be set down.

- **IMPACT:** The DASC needs the ATO in a timely manner and in a useful format. Consistent, successful receipt via the LAN on Desert Storm seems to suggest that this is a good way to receive the ATO provided that the LAN is available. The other ways of receiving the ATO (courier, teletype, tactical FAX) are still available if a LAN isn't.
- Ideally, the DASC would need to be capable of receiving the ATO either directly from the joint level or from the Marine Corps TACC. In either case we would like to be able to manipulate the ATO in such a form as to be readily usable to the aircraft directors, the SAD and anyone else who needs it. (Many man-hours are spent "busting the frag:" copying the applicable portions of the ATO onto RIO sheets and/or making up time-lines so that it is usable)

- If we have the luxury of receiving the ATO digitally, a manipulative program in the UYK-85 could be used to separate out helos from fixed wing, arrange the information into kinds of columns that we like to see, filter out unnecessary information, make up time lines to show mission groupings, and generally save time and effort. One Marine using such a program could prepare RIO sheets for the directors and time lines for the SAD in minutes. For record purposes, information could be quickly extracted by mission type, ordnance type, aircraft type, etc., and sent to the TACC without taking up a lot of valuable time..." (Desert Storm Initial Debrief Synopsis, 9 April 1991, p. 6)

The users identified the following required capabilities during Phase II (selected automation) of the IDASC project in order of priority:

1. Receive and print out the ATO in MTF or MTS format.
2. Manipulate the ATO into formats desired by the user.
3. Receive and print out PLRS information.
4. Send, receive and print out DCT messages.
5. Automatically record and file Tactical Air Request (TAR's), Bomb Damage Assessments (BDA's) and other DASC related information.
6. Extract statistical information from automated files.

G. SUMMARY

It is necessary to realize that the Marine Air Command and Control System is fundamentally a tool that decision makers use. It is a collection of equipment, personnel, and procedures that help the ACE commander gather, process, and disseminate information. Within the present DASC, coordination of air support requests with the FSCC, the receipt, storage, display, manipulation, and dissemination of the ATO and FRAGOs, and retrieval and display of operational data are largely manual. The system is rapidly becoming deficient in its ability to perform its tasks. An increasing amount of

information has generated the need for selective automation of parts of the system. Given the current DASC and the related ATO operations, what aspects of the overall process can be automated effectively? The next chapter specifies requirements which address this question.

III. DASC/ATO REQUIREMENTS

A. GENERAL

This chapter discusses the following issues involved when designing a database processing system for the DASC:

- information processing requirements
- hardware concepts and problems in the battlefield environment
- man-machine interface considerations
- data communications
- interoperability
- system security issues

Background information about the IDASC project will be summarized first to show the constraints and scope of the needed database application. Internal and external interaction requirements and constraints of the system will be briefly discussed to determine the demands placed on the design of the equipment and the applications. The information flow requirements discussed last will serve as a blueprint for database design and implementation addressed in Chapters IV and V.

B. IDASC PROJECT SUMMARY

The IDASC is the designation given to the AN/TSQ-155(V) operations shelter. The shelter houses the personnel and equipment required of the DASC to perform its mission.

To avoid confusion because of pending modifications, the IDASC will be referred to as the AN/TSQ-155 when in reference to the system or DASC when implying the operational function. The DASC supporting system prior to the AN/TSQ-155 was fielded during the 1960's and was designated the AN/TSQ-122. The AN/TSQ-122 was unable to satisfy increasing operational requirements and was fully replaced in 1989 by the AN/TSQ-155. The acquisition was initiated to satisfy requirements exclusive to the U.S. Marine Corps. There was no joint or foreign service participation. During May 1989, the Naval Electronics Systems Engineering Center (NAVELEXCEN) was tasked to act as the In-Service Engineering Agent (ISEA) for the IDASC improvement program. After reviewing operational effectiveness, it was determined that operational deficiencies existed and the Required Operational Capability for the DASC was revised leading to a phased system upgrade.

Phase I modifications to the AN/TSQ-155 are near completion. Phase II (selected automation) and phase III (downsizing/improved mobility) upgrades will be accomplished concurrently by coordinated design/developmental tasks that will create a new entity for the DASC, a vehicle mounted shelter with an integrated command post extension tent and equipment that will provide automated capability. The automated capability improvement will be compatible with and interchangeable between the "Mobile DASC" and the AN/TSQ-155.

A primary goal is to populate the DASC with Non-Developmental Item (NDI) or off the shelf computer equipment and software. The system will use hardware from the Marine Tactical Command and Control System (MTACCS) Common Hardware System

(MCHS) and will consist of rugged computers capable of handling a large volume of information. The DASC computer terminal will be capable of interfacing with a variety of communications equipment to include tactical radios, tactical switches, tactical FAX, and tactical LANs.

The DASC system will incorporate software from the MTACCS Common Application Support Software (MCASS). System software will provide the DASC with a set of automated tools to assist in the performance of its functions. These tools should have the following capabilities: word processing, message preparation and processing, tactical information database, digital message management system, overlay generation and distribution, database management system, database query capability, and hard copy text and graphics. These tools will enable the DASC to fulfill the user requirements of updating, displaying, and controlling the ATO and DASC related information from automated files. Application software will reflect the specific requirements of the DASC and be capable of running on the system hardware and use system software. Additionally, each operator requires a position which provides a workstation and allows individual access to intercommunications and common display information. (Draft ROC, p. 11)

C. BATTLEFIELD REQUIREMENTS

The hardware and software used by the DASC must be able to operate in all combat environmental conditions. It must be capable of operating in a tent or open field while mounted in military vehicles, and be transportable with ruggedized carrying/shipping boxes. Physical environment factors to be considered include temperature, humidity, sand

and dust, air pressure, shock and vibration, rain, fog, and salt water. Furthermore, electromagnetic pulse (EMP) and interference, as well as radiation security (TEMPEST) standards must be met. Finally materials used must be resistant to chemical agents and chemical decontaminants. Human factors engineering must be applied to allow human operators in all mission-oriented protective postures to use the machines in the battlefield environment. The size and weight of the components should allow for 'one-marine carry'. The system should have visual indicators and messages easily readable in all ambient light conditions. The storage hardware must be capable of rapid emergency destruction to enable protection of classified data. Redundancy both in data storage and power requirements must also be planned. These battlefield environmental constraints will have an effect on the physical design of the hardware as well as the architecture of the whole system including its interfaces.

D. SYSTEM INTERFACES

The DASC must interface with agencies internal and external to the MAGTF. In order to fulfill these requirements, numerous intra/interoperability interface networks have been constructed; however, some interoperability requirements are projected as future requirements.

The system must also interface with the required MACCS and MTACCS agencies. Projected interoperability interfaces include elements of the Naval Tactical Air Control System (NTACS), the Air Force Tactical Air Control System (TACS), the Army Command and Control System (ACCS), and allied air support control units as required.

The DASC system will affect interoperability in accordance with the Marine Tactical System Technical Interface Design Plan (MTS TIDP) and United States Message Text Format (USMTF).

1. Marine Tactical System

The MTS TIDP provides USMC Tactical Data Systems (TDSs) with intraoperability message, data elements, and protocol standards. The interface design plan decomposes Marine Corps Command and Control Facilities (C2FACs) of the MTACCS interface requirements into specific data link protocol and message/data implementation requirements. It also provides the data element standard for data field identifiers (DFIs), data use identifiers (DUIs), and data items (DIs) that support the MTS standards. The message standards in volume IV of the TIDP contains approved Marine Corps messages with information on message purpose, structure, data content, and format. The transmission format (physical order and sequence of the fields) are presented on text information sheets within the TIDP. The MTS Message Formatting protocol provides message formatting that allows the system to be independent of the communications system.

2. Message Text Format

The USMTF program is designed to provide a uniform reporting procedure to be used in all defense conditions and to reduce the time required to draft, transmit, analyze, interpret, and process messages. The message text format (MTF) program improves information exchange by producing messages which are both human readable

and machine compatible. The program also has the objective of facilitating the exchange of information between the United States and Allied commands and reducing or eliminating dual reporting by US units when they operate with Allied command/units. The MTF program describes what is in reality an artificial language with its own definite structure, vocabulary, and syntax. The MTF ATO message format is listed in Appendix C.

3. Communications

Communications requirement considerations include capacity, response time, connecting and addressing, integrity, control, security, and transmission medium. The demand for communication will not be constant but the demands for data transmission capacity and response time must be met by the communications system. Connecting and addressing protocols must provide a means for identifying the intended recipient of a transmission. The transmission medium must preserve the integrity of the information it handles. Control protocols must be applied to channel and transmission medium between computer-based information systems. The security of the information must be preserved by the communication system. Redundancy in the transmission medium must be planned. This redundancy may be single or multi-channel radio, satellite communications, copper cables or fiber optics.

E. MAN-MACHINE INTERFACE

Rice states that "the design of the ... man-machine interface (MMI) will be crucial to the efficient working of the system ... it provides the user with a window through which he may view the system and a set of controls to enable him to drive it." (Rice, p. 82) Simple interfaces consist of a way to insert/extract information into/from the system, and to direct the system what actions to take. The MMI includes the hardware and the software for this process. The dialogue used in this process determines how "user-friendly" the system is.

Input devices consist of keyboards and pointing devices. A pointing device such as a tracker ball or mouse moves a symbol on the display to a desired position. Pointing to the desired position on the screen itself with a finger or instrument is another type of input.

Output devices include either temporary or permanent display units. Temporary displays consist of visual display units such as cathode ray tubes (CRT), liquid crystal displays (LCD), gas plasma display, and projected displays. Permanent displays which deliver a hard copy may be either printers or plotters. Printers are usually limited to text or simple graphics while plotters can produce images along an x and y axis. Laser printers combine the qualities of both a printer and a plotter.

Other interface technologies under consideration are voice recognition for input and speech synthesizers for output.

The design of the dialogue between man and machine will determine how the user interacts with the system. The MMI should be easy to use for both the inexperienced and

the familiar user, consistent, and optimized for the task being performed. (Rice, p. 96)

A context-sensitive "help" key which explains the task being performed is an example of this trait. Consistency standardization refers to the way tasks are to be performed. A simplified example of inconsistency would be imputing 'Y' or 'N' in one application program while requiring 'YES' and 'NO' in another. Pointing devices should also maintain consistent operations. Optimization for the task being performed means that the user should not have to access a large number of displays to perform his job.

Styles of MMI that conform to the requirements above include a keyboard based MMI, a touchscreen based MMI, and the windows, icons, menus and pointer (WIMP) approach to MMI. (Rice, p. 98) Menu selection refers to a range of choices presented to the user on the screen. The input by the user will lead to other menus or to the task requiring performance such as entering form information. These layers of menus are referred to as the depth of the application and may be described as a tree structure. Experienced users should be able to jump between layers, while a user who finds himself confused about his location in the menu dialogue should be able to return directly to the main menu.

Keyboard based MMI are useful in data entry systems. A menu can lead the user to the correct form and then a form layout can assist the user in entering information. Shaded areas can highlight required inputs.

Touch screens can be interchanged or incorporated with keyboard based MMIs, using graphical representations that prompt the user to touch the screen for the desired result.

The WIMP approach to MMI offers benefits which include consistency and multiple tasking. Windows are an area of the screen dedicated to a particular task. Icons graphically represent a resource or action to be preformed. When combined, they approximate the way a user may organize his tasks.

The following examples of consistency include retrieval and saving of documents. All files are opened by pointing to an associated icon. Saving a file is accomplished by 'dragging' it to a file cabinet icon and then clicking a button on the mouse to indicate the document is to be saved.

Multiple tasking involves being able to work on two or more applications at the same time. For example, while working on a word processing document, the user may open a window, retrieve data from a spreadsheet and then 'cut and paste' this information into the original document. This example of multiple tasking demonstrates one of the advantages of the WIMP or graphical user interface (GUI) approach to MMIs.

The choice of MMI will be determined by the required tasks and battlefield environment. Because the users in the air support community are often resistant to automation, these design decisions are critical to the acceptance of the entire system. Automation must both improve efficiency through user friendliness, and provide useful information. MCTSSA, representing the user community, must stress the importance of user friendliness and insure user involvement with the designers, developers and programmers of the MMI.

F. INFORMATION FLOW REQUIREMENTS

Although the DASC consists of many crew members performing separate functions, we will treat the DASC as a "black box" and concern ourselves with the external information flow of the DASC rather than the internal coordination of the DASC crew. The DASC crew will interact with different applications designed for their specific functions. The information flow of the DASC that pertains to the user requirements defined in Chapter II is depicted in Figure 5 and includes: the ATO, mission requests, mission status, aircraft status, and battle damage assessments. Each is considered in turn. The appropriate forms are displayed in Appendix 3.

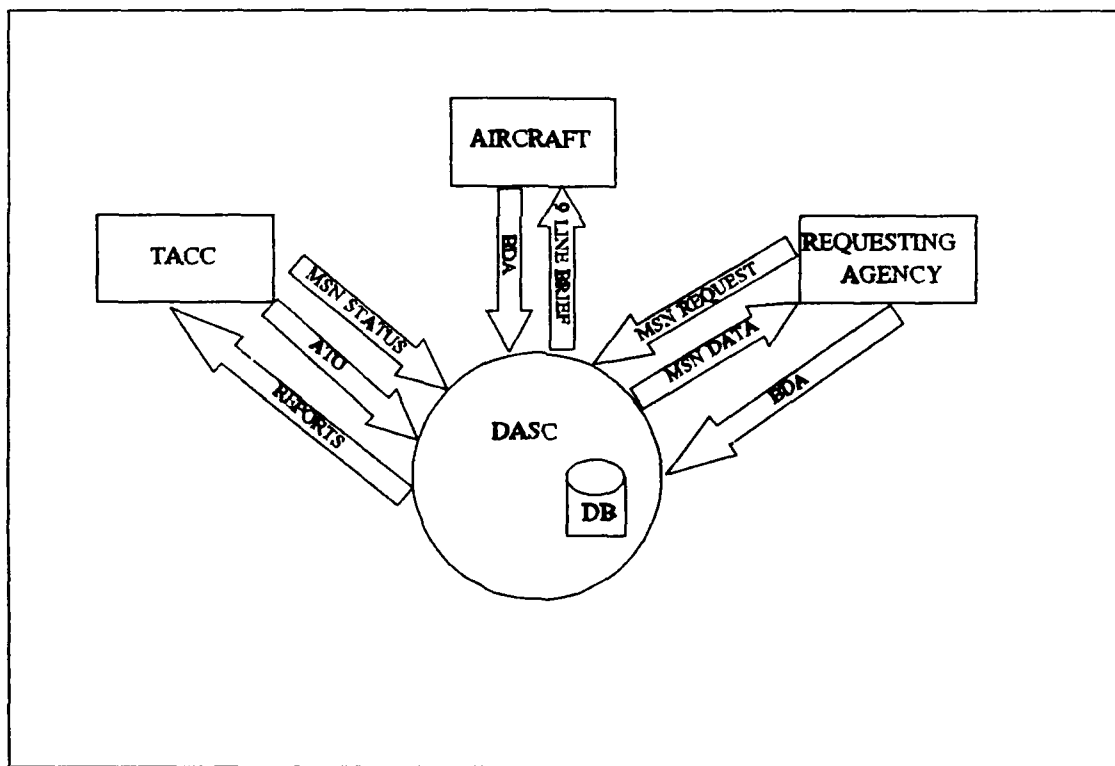


Figure 5. DASC Information Flow

1. ATO

The ATO is received by the DASC daily. Updates or changes to the ATO can be received at any time. The MTS message includes the effective time period, tasked unit(s), and basic mission information: mission number, request number, priority, mission type, time on and off target, alert status, location, callsign, number and type of aircraft, ordnance type, IFF/SIF mode and code, and time and target location.

2. Mission Status

Mission status refers to the information that an appropriate MTACCS agency sends or requests on aircraft assignment data. The status may pertain to preplanned, on-call, or immediate missions. The information may pertain to any data on the ATO.

3. Mission Requests

Requests to the DASC for direct air support can come in the form of tactical air requests or assault support requests. Voice communications discussed in current operations use the JTAR or ASR forms. MTF message standards utilize the Air Support Request (AIRSUPREQ) format. The DASC may assign subordinate controlling agencies mission data and brief the aircrew using the 9-line brief format.

4. Aircraft Status

Aircraft status/availability reports are made to the DASC pertaining to aircraft in a strip alert status. If the DASC has launch authority of the aircraft, information would include number and type of aircraft available during specific time periods with specific ordnance and strip alert times.

5. Battle Damage Assessment

The purpose of the BDA is to convey the pilots' or controllers' damage assessment, ordnance expended and ordnance remaining. The DASC receives the information and relays it to the appropriate MTACCS agency.

6. Reports

The DASC may be required to submit operational summary reports based on the operational events during a specified period.

G. SUMMARY

The DASC system requirements discussed in this chapter defined the computer hardware, software, security and communications considerations that require attention when designing systems that can survive on the battlefield. By establishing the information exchange requirement of the users as applied to the ATO, we are now able to look at database processing alternatives for developing a database application for the DASC.

IV. DASC DATABASE APPLICATION

A. GENERAL

The user requirements and information flow discussed in the previous chapters will provide the basis for the logical database design developed in this chapter. The Entity-Relationship (E-R) approach is utilized to develop the logical database design. The data is normalized using an E-R modeling tool. The use of these methods will demonstrate the potential for designing and implementing a relational database application within the DASC.

B. DATABASE OVERVIEW

Database technology was developed to overcome the limitations of file processing systems. In database systems, all application data are stored in a single repository called a database. (Kroenke, p. 10) It is a collection of related data designed and built for a specific purpose, intended for use by a known group of users, representing some aspect of the real world. Database processing eliminates the dependency of programs on specific file formats which cannot be shared easily by other programs. DB processing allows different users to share the same data thus minimizing duplication and update problems caused by redundant data in file processing systems. Unlike file processing programs, database processing programs do not require file and record formats. (Kroenke, 1987, p. 11) File formats are stored in the database and accessed by a database management

system (DBMS). This arrangement of data, called program/data independence, is the primary objective of a DBMS.

Database applications are developed so users in different functional areas can retrieve information from a common database without interfering with one another. Database systems provide mechanisms for updating, displaying, and controlling the data.

A database model is a representation of a physical database. It shows the physical files, the access paths between the files, and the data items in each file. Database models are defined by the way data is organized, stored, and manipulated. Traditional file processing systems use flat files where relations between files are defined by the application programmer. The emergence of DBMSs led to different concepts in database architecture, and the way data is linked to the database and the application.

The primary database models are the hierarchical, network, and relational models. In the hierarchical and network models, the application programmer must know the physical structure in order to navigate through the database. This structure can become very complex to learn and is quite demanding on the user and/or programmer interacting with the database. The conceptual structure matches the physical structure tying the data to the application. This results in a high level of maintenance because changes in the application data requirements force changes in the defined data structures. (Brackett, 1987, p. 6) These weaknesses have led to a third method of data modeling based on relational theory.

Relational database architecture is an environment in which data are viewed as tables, or relations, and multiple tables can be associated or related to one another based

on common data items or fields within the tables. The physical relationships are defined at execution time based on the application needs. This model contrasts with the hierarchial or network models which require pointers or links in each data record. Since there are no predefined relationships in relational databases, the structural detail is minimized. This results in lower database maintenance, making it easier to control database changes, and provides flexibility by facilitating the definition of dynamic logical relationships (Brackett, 1987, p. 5-6). Reports or processes can be added without having to modify the structure, and changes made to a data item will be reflected in every related record.

Knowledge of relational model terminology will assist in understanding the logical database design presented below. The relational data model files appear as flat files, or tables to the users. A *relation* is a table containing data about an entity or object that obeys certain rules. An *entity* is a real world thing. Each relation deals with a single entity and each row in the relation is an instance or occurrence of an entity. A *tuple* is a row in the table, an *attribute* is a column. There is no order to the tuples and attributes. Each attribute has a *domain* of values which can be assigned to any instance of an attribute. A *key* is a group of one or more attributes that uniquely identifies a row. The *primary key* is a unique identifier for the table. A *foreign key* is an attribute on a relation that contains the primary key of another relation in order to relate one table to another. Figure 6 is an example of a relation.

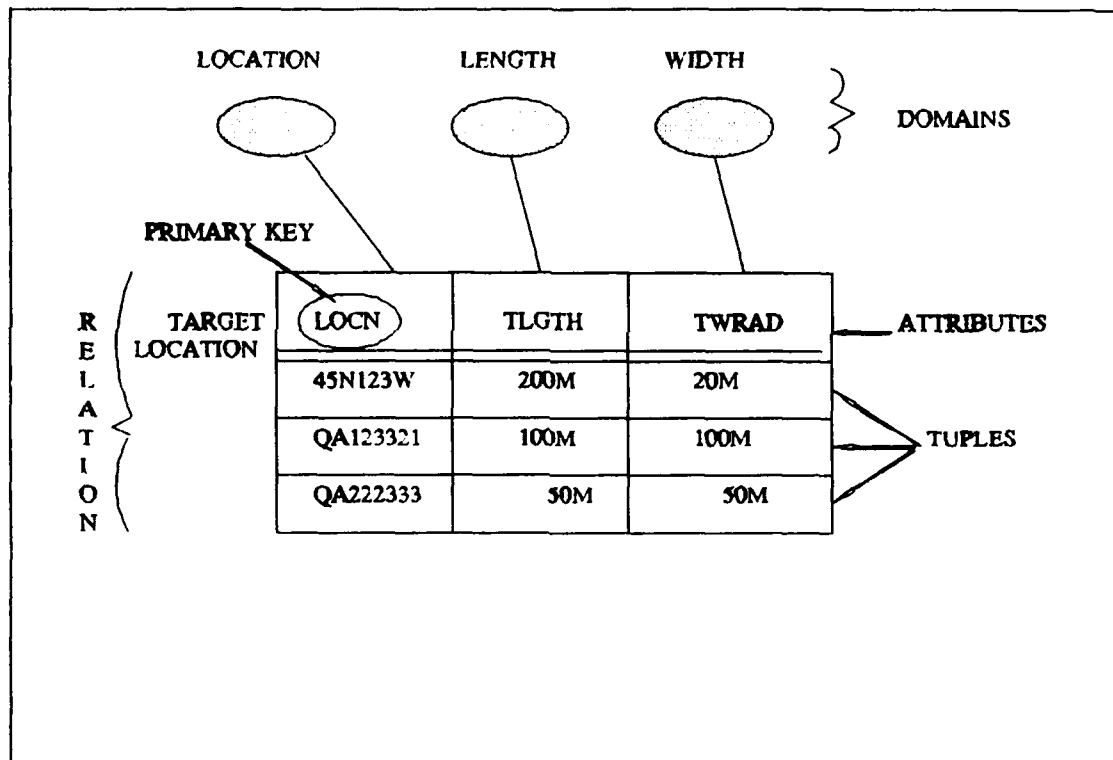


Figure 6. Example of a Relation

C. DATABASE DESIGN

The goal of the design phase is to develop a model for one or more applications that will support current and future operations. Database design includes the definition of tables, attributes, and relationships among tables. The design methodology used in this thesis is summarized in Figure 7.

The *schema* is a formal definition of the logical records that make up the database and the ways that relationships among records are represented. Logical database design transforms the formal representation of entities and their relationships, called a conceptual schema, into a processable schema for a given system application. The logical data structure (LDS) is a graphical depiction of the four components: entity, attribute, identifier, and relationship. The identifier describes the entity, attribute, or relationship

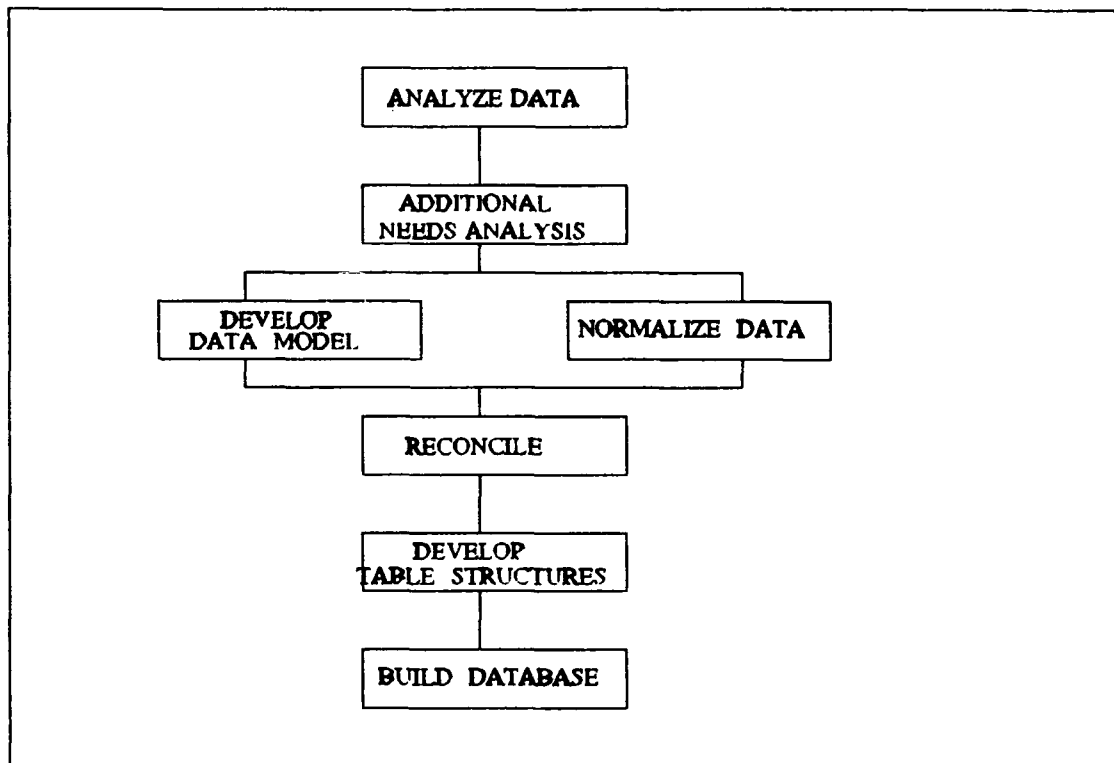


Figure 7. Database Design Process

(e.g., LOCN identifies an attribute in Figure 6). A collection of LDSs describing the conceptual information structure is determined by the user. For the DASC application, the database requirements defined in the Information Flow Requirements section of Chapter III require that the user be able to receive the ATO, to archive and extract information from it, and manipulate it into desired formats. The ability to record and file immediate requests, BDAs, and other DASC related information, and to query the database to extract statistical information is also required. Entity-Relationship modeling, a top down approach to data modeling, helps the designer to capture data requirements and transform them into a logical data structure and user schema.

1. Entity-Relationship Model

The Entity-Relationship (E-R) approach is unique among database design techniques in that it can be used to design a database independent of the underlying database model (hierarchical, network, relational). It is based on a theoretical foundation of relational algebra, and aids in communication between designers and users. The E-R modeling steps are:

1. classification of entities and attributes
2. identification of generalization hierarchies
3. determination of the relationships among the entities
4. definition of the mapping cardinality between each relationship and entity.
(Teorey, 1990, p. 55)

The E-R model uses entities to represent a real world thing, object, or concept (e.g., *ATO*). Entities contain descriptive information called attributes (e.g., *ATO* contains *Start Time*, and *Stop Time*). Attributes that may be repeated in an entity are called multivalued attributes, and will be classified as separate entities (e.g., *ATO* has a repeating *ATO Mission* field, will be decomposed into a separate *ATO Mission* entity). Attributes should be attached to the entity they best describe. An entity can usually be described by a noun. If one entity is dependent on the existence of another entity (e.g., *Mission Data* is dependent upon *ATO*), then that entity is described as a weak entity. A gerund is a relationship converted to an entity (e.g., customer ships a product, but the shipping

is done by clerks). If entities relate to themselves (e.g., *person-married-person*), then the relationship is called recursive.

A relationship is an association between two or more entities. Relationships are usually described by verbs in the E-R diagram (e.g., *ATO contains Mission Data*). The degree of a relationship is the number of entities associated with the relationship. A relationship with n associated entities is called *n-ary* (e.g., unary (1), binary (2), and ternary (3)). An entity is a ternary relationship if an instance of an entity can be associated with one instance of each of two associated entities. An example is the three entities Mission, JTAR, and Unit associated by the relationship "*requests*".

Values associated with the connectivity between entities are "one" or "many". The number associated with the term "many" is called the *cardinality* of the connectivity. Functional dependency refers to the relationship between attributes. If, when given a value of attribute x , one can determine the value of attribute y , then y is said to be functionally dependent on x . When two attributes functionally determine each other, a 1:1 relationship occurs (e.g., Control Agency determines Callsign, and Callsign determines Control Agency). If one attribute functionally determines another but not the reverse, a 1:M relationship occurs (e.g., Callsign determines Mission Number, but Mission Number does not determine Callsign). Finally, if neither attribute is functionally dependent on the other, a M:M relationship occurs (e.g., Mission Number and Request Number do not determine each other). (Kroenke, 1987, p. 163)

Participation rules may also pertain between entities. Obligatory participation requires that every instance of an entity must participate in a relationship (e.g., all BDAs

must be assigned to a Target). Non-obligatory participation is an instance of an entity not needed to participate in a relationship (i.e. a BDA *may* exist with no JTARs). A generalization/specialization (*ISA*) occurs in a relationship when an entity is partitioned by different instances of a common attribute. An example is the entities *Mission Location* and *Target Location* which share the common attribute *Location*, but have distinct attributes associated only with that generalization/specialization (e.g., *Mission Location* has the attribute *Location Type*, while *Target Location* has the attribute *Target Type*). In the example above, *ATO Mission* can contain either a *Target Location* or a *Mission Location*.

When translating the E-R model to the relational approach, each entity becomes a table, each attribute becomes a column in the table, the unique identifier becomes the primary key, and that primary key becomes a foreign key on the many side of 1:M relationships.

2. Normalization

Relations are often defined in a form that suffers from problems in terms of integrity and maintainability. Updates to a database may result in the elimination of useful data as an unwanted side effect. Also, when the data is defined as a single large table, updates can result in large amounts of redundant data. Classes of relational database forms, called normal forms, are defined to avoid these problems and maintain high integrity and maintainability. The process of creating the appropriate normal forms is called *normalization*. (Teorey, 1990, p. 91)

Normalization is a process of assigning attributes to the appropriate entities. It is a bottom up approach to data modeling. The principles of normalization dictate that data items belong together in a logical group, and these groups can be identified by their own unique identifier or key. The data in each group should describe one, and only one thing. Normalization for the relational model usually requires normalizing relations to Boyce-Codd Form, or the equivalent as defined below.

Recalling the definitions of a relational data model, all relations are said to be in first normal form (1NF) if they have non-repeating groups within a tuple. Consider the relation:

ROUTE (Point Number, Location)

where *Location* represents the location of a point. This is a repeating group for multiple missions because different locations may be assigned the same point number for separate missions. To fix this, the relation would become:

ROUTE (Point Number, Mission Number, Location)

where each location would have a separate tuple.

A relation is in second normal form (2NF) if it is in 1NF and all non-key attributes are dependent on the primary key. An example would be the Route relation used earlier:

ROUTE (Point Number, Mission Number, Location, Mission Type) where

Mission Number --> Mission Type

The non-key attribute is dependent on part of the primary key. To fix this the relation is decomposed into the following two relations:

ROUTE (Point Number, Mission Number, Location)

MISSION (Mission Number, Mission Type)

A relation is in third normal form (3NF) if the above exists and there is no non-key attribute determined by anything but the key (transitive dependency). A relation in violation of third normal form would be:

ROUTE (Point Number, Mission Number, Location, Location Comments)

where Point Number, Mission Number --> Location

Location --> Location Comment

This is in violation because *Location*, a non-key attribute determines *Location Comment*, another non-key attribute. This is fixed by decomposing the relation into two relations:

ROUTE (Point Number, Mission Number, Location)

LOCATION (Location, Location Comments)

Finally, a relation is in Boyce-Codd Normal Form (BCNF) if every determinant is a candidate key, or no anomalies regarding functional dependencies exist. BCNF deals with relations with overlapping keys. An example of a relation with overlapping keys is:

ROUTE (Point Number, Mission Number, Location, Point Name)

where Point Number, Mission Number --> Point Name

Point Number, Location --> Point Name

These are overlapping keys because both keys contain *Point Number*. To fix this problem, the relation is decomposed into two relations:

ROUTE (Point Number, Mission Number, Location)

POINT (Point Number, Point Name)

A decomposition is said to be *lossless* if it preserves the functional dependencies of the original relation. For example if the two decomposed relations above are joined, the resulting relation will be equal to the original relation.

The bottom-up, or normalization approach in developing a logical database design will result in the relations being normalized to the degree required, usually, a collection of tables in BCNF. The resulting processable schema allows the DBMS to physically manage the database.

D. SCENARIO

To model the user defined requirements, a simple scenario will be described based on current operations in the DASC. The DASC will be treated as a "black box" i.e., ignoring its internal functions. Likewise, external agencies will be ignored. The E-R model is concerned only with the information requirements of the DASC, not the means by which information was transmitted or received, or its origin or destination.

The scenario is as follows:

1. The DASC receives the ATO and manipulates it for display on the appropriate log (FRAG).
2. The DASC receives JTAR 26-1 and processes it, assigning a mission to execute it.
3. The DASC transmits mission data to the requestor and requests launch of the assigned mission.

4. The aircraft reports to the DASC, the DASC briefs the A/C using the 9-line brief format, and turns the A/C over to the terminal controller at the appropriate control point.
5. The DASC requests mission status on a rotary wing mission.
6. The A/C executing JTAR 26-1 checks out with the DASC, mission complete, with a BDA.
7. The DASC receives a change to a preplanned mission.
8. At the end of the day, the DASC transmits an operational summary (OPSUM) report.

E. DASC DATABASE DESIGN

Relational database application capabilities will be demonstrated by extracting information from the current databases used in the DASC. This involves combining the automated files (MTS ATO), non-automated data (immediate requests, RIO logs, BDAs, operational summary), and user requirements discussed in Chapter III.

This information provides the basis for determining the entities, attributes, and relationships for the E-R diagram. The abbreviations and field structures of the identifiers duplicated the existing MTF and report formats where applicable. The following entities were identified to pertain to the DASC ATO application:

- AIR TASKING ORDER - defines time period and type of ATO
- BATTLE DAMAGE ASSESSMENT - defines mission results of a particular target
- CONTROL AGENCY - defines characteristics of a particular control agency
- IMMEDIATE REQUESTS - defines unit supported for an immediate air support request

- **MISSION (ATO MISSION)** - defines basic characteristics of the particular mission to include aircraft data
- **MISSION LOCATION** - defines mission location
- **RECEIVING AIRCRAFT** - defines mission data for aircraft requiring refueling
- **RECONNAISSANCE** - defines reconnaissance data
- **RECON TARGET** - defines reconnaissance target data
- **RIO LOGS** - defines actual mission data
- **ROUTE** - defines mission route information
- **TARGET LOCATION** - defines mission target data

The relationships defined between entities depicted in Figure 8 include:

- **ASSESSES** - BDA may be reported on a **TARGET LOCATION**
- **COMPRISES** - ATO is comprised of various **MISSIONs**
- **CONTROLS** - **MISSION** is controlled by various **CONTROL AGENCY(ies)**
- **INTEREST IN** - **RECONNAISSANCE** mission executes various **RECON TARGETs**
- **MAY DESIGNATE** - **MISSIONs** may follow certain **ROUTEs**
- **REFUELS** - **MISSION LOCATION** may refuel **RECEIVING AIRCRAFT**
- **REQUESTS** - **IMMEDIATE REQUESTS** request **MISSION** to perform
- **UPDATES** - **RIO LOGS** update the ATO with actual mission data

Mapping cardinality between each entity was specified to complete the diagram.

Appendix D lists the cardinality rules used for each link.

Figure 8 depicts the resulting E-R diagram using an E-R modeling tool called E-R Designer by Peter Chen and Associates. Appendix D lists and explains the entities,

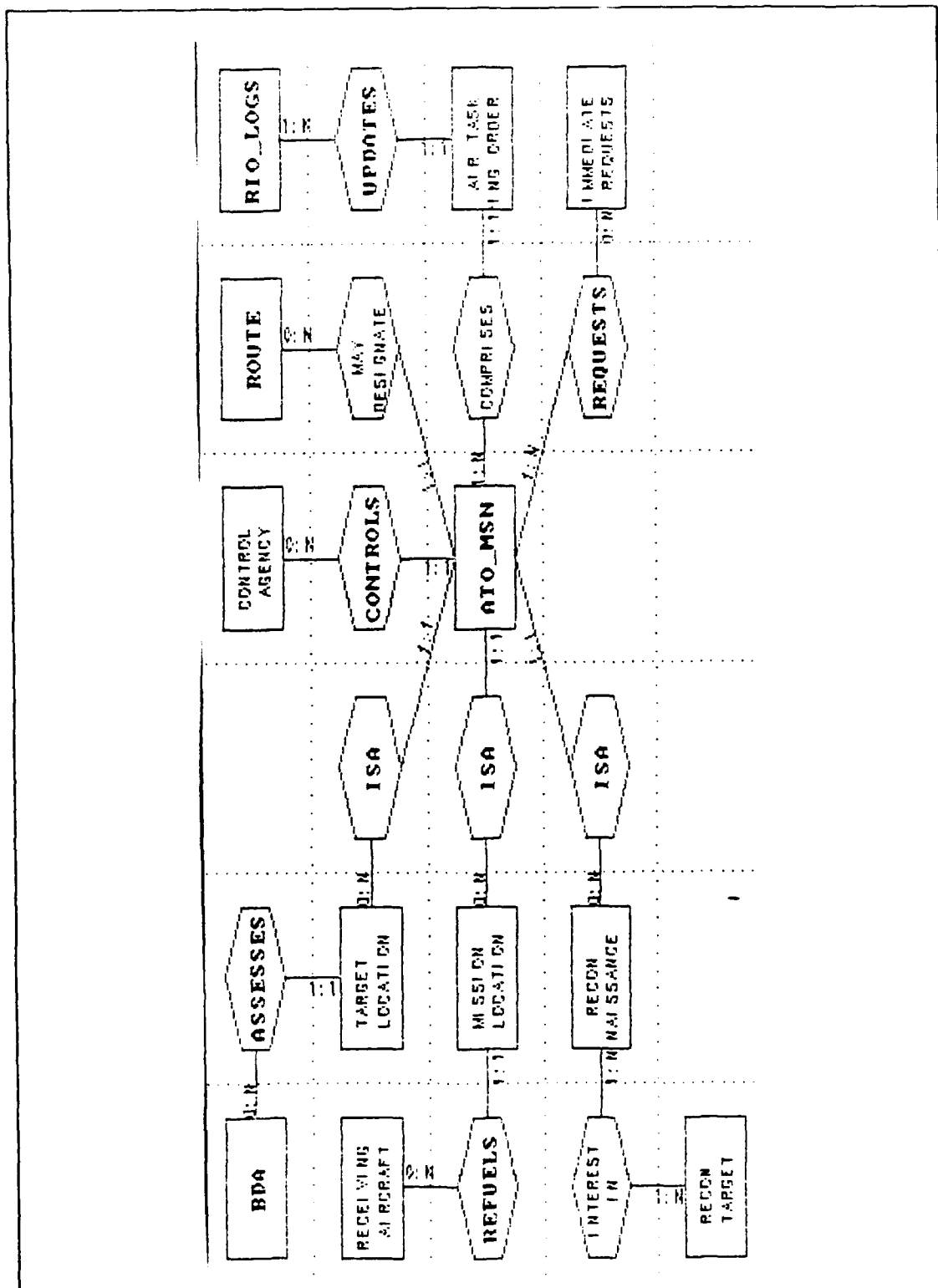


Figure 8. Entity-Relationship Model

attributes, relationships, and cardinality rules depicted on the E-R diagram.

The entities *BDA* and *Target Location* linked by the relationship *Assesses* will be used as an example of how to read the diagram: There can be as few as zero or as many as N (many) *BDAs* assessing each *Target Location*; and there can be one and only one *Target Location* assessed in each *BDA*. The term 'ISA' refers to a generalization occurrence on the entity *ATO Mission*. *ATO Mission* must have one of the entities; *Target Location*, *Mission Location* or *Reconnaissance*, as a member.

The E-R model was then loaded into the Normalizer tool of E-R Designer to validate the schema. The initial schema generated by the E-R Designer tool is shown in Appendix E. Functional dependencies (FD) were defined in each relation. The normalizer tool normalized the relations to the BCNF and decomposed the relations into FD-preserving and lossless-join 3NF relations. It also ensured that complex relations were broken down into simpler ones in which related data items were grouped and duplication minimized. The user interaction log for defining the functional dependencies is listed in Appendix F. The resulting schema from the Normalizer tool is displayed in Appendix G.

F. IMPLEMENTING THE DASC SCHEMA ON A RELATIONAL DBMS

The relational schema developed in the previous section is not linked to any specific DBMS. No database package meets all the features and qualifications of a "fully relational" database; however, many relational databases exist that can use the schema

generated. To demonstrate the potential of a relational database, dBASE IV is used as a prototype implementation of the DASC application.

A DBMS is a program, or set of programs, that processes the database. The DBMS allows the user to create, maintain, and access a database. The DBMS allows the program to be separate from the application. The application can be thought of as a collection of menus, forms, reports, and programs that satisfies the needs of a user or group of users. The DBMS is a set of programs or tools which allows developers to design and implement a system which users can access. (Kroenke, 1987, p. 62) The features and functions of a DBMS include:

- Change the data as the real world changes
- Support a data structure that corresponds to the real world
- Protect the data from corruption from authorized users
- Protect the data from unauthorized users
- Support access to data by multiple users simultaneously
- Recover from software and hardware failures
- Get information out of the database easily
- Improve productivity of the development programmers
- Reasonable performance

A database was created using the normalized relational schema field format developed by E-R Designer. A simulated ATO was loaded into the database. Reports were generated linking tables to get the desired outputs. Ad hoc queries were conducted

to determine the application capabilities. Sample reports and queries are listed in Appendix H.

Database generation creates an actual physical structure which is generated from the conceptual schema. The DASC application schema created by E-R Designer and listed in Appendix G determined:

- database names
- field names
- field types
- field length

The data files created above were used to define the database structure in dBASE IV. dBASE IV uses a main menu called the Control Center to access and store files. dBASE IV achieves the functions of data management (creation, interrogation, updating, administration) through the Control Center. For example, the relation *Air Tasking Order* was used to create the database file *ATO* in the Data Panel. Field names were derived from the attributes *ATO Start*, *ATO Stop*, and *Air Tasking Code* using the attribute type (character or numeric) and length as shown in Appendix G.

Unless otherwise specified, dBASE IV stores records in the order in which they are entered. dBASE IV can be manipulated to store and retrieve data in a sorted order by physically rearranging the records. Another way to sort, or retrieve, data is by creating an index field on a field value. Indexes allow data to be retrieved "directly" rather than by doing a sequential search, thus indexing makes some retrievals more efficient. For

example, since the DASC ATO application will require information on particular mission numbers, the *Mission Number* field was indexed when delineated in a database (relation).

Once the database structures were created, data was loaded into the appropriate databases. An ATO was developed consisting of seven missions. Manual insertion of data was done ensuring all tables contained some data. The actual DASC application will require a compiling program and parser to automatically upload MTS data to the DASC application.

The next step was to create database queries and views. A query is the retrieval of a specific table, possibly requiring the join of two or more tables, to meet a stated condition. Queries may require that data be drawn from multiple tables. dBASE IV uses views to help with query operations. In general, a view is a virtual table which is a subset of one or more existing tables in the database. In dBASE IV, it's actually stored physically but this is not how all DBMSs do views. For example, a mission status may be requested on a troop lift from the DASC. The DASC would use the DASC application to find this information by creating a view linking the attributes of *A/C Status* database with the *A/C Weapons* database. A query is made on this view listing all records whose *A/C Type* field type is "CH-46". This query would create a view of the mission data of mission "30H0002". These queries can be permanently stored in the Queries panel of the control center in dBASE IV.

Forms files display customized screens. This can be used for entering, updating and displaying data on a particular form. The custom form can be created using the tools in

dBASE IV. An example is the *Battle Damage Assessment* form contained in Appendix H. Forms may also be created using the special views created in the queries panel.

Reports can be generated in dBASE IV from one or more tables using the above procedures. The reports can be printed or displayed on screen. Appendix H contains a sample Report-In/Out Log and Immediate Air Support Summary Report.

Design and implementation of the DASC schema as described above is the responsibility of the Database Administrator (DBA). The DBA must ensure that the integrity of the underlying DASC database is maintained at all times. This entails a number of critical functions as described next.

G. DATABASE ADMINISTRATION FOR THE DASC DATABASE

Database Administration is a technical function that is responsible for physical database design and for dealing with technical issues such as security enforcement, database performance, and backup and recovery. (Hoffer, 1991, p. 339) The Database Administrator for the DASC database will need to be involved with the following:

- referential integrity
- concurrency control
- backup and recovery
- database security
- handling missing data
- training

1. Referential Integrity

Referential integrity is concerned with the validity of references by one object in a database to some other object(s) in the database. Rows in one relation may refer to a row in another relation, and problems can occur when inserting/deleting data. A referential integrity constraint requires that for each row of one table, the "referencing table", the value of the foreign key value must be the same as the value of the corresponding primary key column in some row of the referenced table or else be null. A row should not be able to be inserted in the referencing table unless it exists in the referenced table. Additionally, a row should not be able to be deleted from the referenced table if there is a matching row in the referencing table. For example, if a mission is deleted from the *A/C Status* relation, then the deletion should either:

1. be deleted in every relation which contains the same mission,
2. be disallowed, or
3. nullify the *mission number* attribute in the referencing table(s).

Referential integrity constraints can be enforced by an application program or by a DBMS that includes facilities for enforcement. dBASE IV does not provide referential integrity facilities.

2. Concurrency Control

Concurrency in a database environment means that more than one user can access and manipulate data at the same time. Multiple users of the DASC database can

compromise the data unless there is concurrency control. An example would be where users A and B both update the relation *Battle Damage Assessment*. User A updates the field *BDA Comment* and saves the data, while user B updates the field *Unit Supported* and saves the data 5 seconds later. The information updated by user A would be lost.

Controlling concurrent access may be done by locking or denying access to other users until the update is completed. Locks may be implemented at different levels (database, table, block, record, field), and may provide shared access but allow only one update user. DBMS products provide different locking capabilities. dBASE IV provides concurrency control by locking records automatically by default, or by locking table access through the *protect* and *exclusive use* commands in the application generator tool.

3. Backup and Recovery

Database recovery procedures are required to restore a database quickly after a loss or damage. The DBMS should have tools to recover data from program aborts, software failures, and hardware failures. In program aborts, the DBMS detects transactions started and aborted without "commit", then effects an automatic "rollback". When a system "crashes" or loses power, the DBMS examines the transaction log once initiated and effects a "rollback" for all incomplete transactions. The database must be restored from a backup copy for hardware failures, and the DBMS must reproduce transactions on log since the backup. dBASE IV, for example, provides automatic "rollback" through the application generator tool. dBASE IV also has the capability to log terminal activities into a text file to produce an audit trail of database

transactions. This audit trail, however, cannot be automatically reapplied to restore the database.

4. Database Security

Data Security protects the data from unauthorized users. The first level of security is physical security. The next is the use of passwords both into the system and into the programs. The DBA can create views for different classes of users controlling the type of access (read, write, delete) each user has to the data.

5. Handling Missing Data

Procedures must be established by the database administrator to handle missing information. Data that is missing, lost, or incomplete in the DASC application must be dealt with in the design phase.

6. Training

The DBA interfaces with the users for training purposes, and to determine ongoing system requirements. DBMS software is complex and consumes resources. Performance is measured in time required to support a function, number of users supported, and number of transactions per second. There is a trade-off between performance vs. features, performance vs. flexibility, and performance vs. portability. Reasonable performance will depend on the balance of these trade-offs. (Hoffer, 1991, p. 363-384)

H. SUMMARY

This chapter discussed and applied the relational theory for data modeling to the DASC application using the E-R approach and normalization. An entity-relationship model created by the support tool E-R Designer was combined with the Normalizer support tool to develop a relational schema for the DASC application. The logical data structure was translated to a relational schema, and implemented on a microcomputer DBMS called dBASE IV. Although further work is needed before the DASC application can be fully implemented as a functional prototype, the potential for this approach and resulting application was demonstrated. The Database Administrator will play a key role in developing the DASC ATO application. A DBMS that provides interactive management facilities will assist the DBA in his responsibilities.

The final chapter summarizes the study's results, and suggests areas for future study.

V. CONCLUSIONS

A. CONCLUSIONS

This thesis developed a logical schema for a centralized relational database, given the requirement specifications for a DASC database application. The thesis illustrates the steps of E-R modeling, normalization, and implementation of the schema using a relational DBMS. Database design is an evolving activity. As user requirements expand and change, the conceptual schema and database structures must change accordingly. The methodology used in the original design is important since it may be reused to keep the database current as more aspects of the DASC application are developed.

The E-R approach is particularly useful in the early stages of the database lifecycle, which involves requirements analysis and logical design. When requirements are determined from end-user interviews and modeled in terms of E-R diagrams, immediate feedback can be obtained concerning the validity of the database. Another advantage of the E-R approach is that the schema is independent of any particular DBMS environment and therefore can be used with potentially many different DBMS platforms.

Once a logical data structure has been generated, it is a straightforward process to implement the schema in a specific environment as we have shown with dBASE IV. The relational DBMS manages ad hoc queries and new applications that would be more time consuming to implement with other models.

Relational databases are easy to design, maintain, and use. They enforce data independence and encourage data sharing. They readily support application development, prototyping, and distributed data applications. Relational architecture will support many applications and is recommended for adoption for implementation of the DASC application.

B. FURTHER RESEARCH

This thesis represents only an initial study into the potential of implementing a relational database application in the DASC. The study examined a passive DBMS where queries and transactions occurred only when explicitly requested by the user or application program. Future study is suggested in:

- design of an active database management system aimed at meeting the needs of applications requiring time-constrained data management and processing. A High Performance Active (HIPAC) DBMS automatically monitors events, evaluates conditions defined over the state of the database when appropriate events occur, and, based on the result of conditions evaluation, invokes actions associated with the event-condition pair.
- evaluation of implementing the database design in SYBASE, the Marine Corps' chosen standard for relational DBMSs.
- evaluation of the alternative file indexing structures of the DASC application. This system performance evaluation should determine the structure with the best performance while minimizing the volume of the database.
- define the structure and content of a database that would support the entire Marine Air Command and Control System and Marine Tactical Command and Control System. Standardization of data elements used within the system should be addressed. Considerations should be given to implementing the design in a distributed database environment.

- development of an expert system for assignment of missions to immediate air requests that interacts with the DASC application. The expert system could be based upon standard operating procedures to assist decision makers in the DASC.
- determine the communication equipment requirements to include parser and compiling requirements for the transmission, receipt, and storage of the ATO. This should include security and integrity checking in the transmission specifications.

APPENDIX A: GLOSSARY

Anomaly - An undesirable consequence of a database modification.

Application - A collection of menus, reports, forms, and programs that addresses the needs of the users.

Attribute - A data element that describes an entity. A column of field in a relation.

Candidate Key - An attribute or attribute group that could be used as a key in a relation.

Command and Control Facility (C2FAC) - An organization element that needs to communicate with another to perform its tasks.

Command and Control (C2) System - The facilities, equipment, communications, procedures, and personnel essential to a commander for planning, directing, and controlling operations of assigned forces pursuant to the missions assigned.

Data - A fact or condition represented in a form that is usable by an Automated Data System including its operators.

Data Item - The smallest unit of named data that has meaning in the real world.

Data Dictionary - A user-accessible catalog of data about a database.

Data Element - Used synonymously with data item.

Data Field Identifier (DFI) - The DFI provides the identification for the class of data relating to a message field in the MTS message standard. The DFI contains a unique number, name, and definition. The DFI is a generic definition of the concept represented by all associated DUIs. All DFIs must have at least one associated DUI.

Data Model - A language describing the structure and processing of a database.

Data Use Identifier (DUI) - The DUI further identifies the functional or categorical context in which the DFI is used. The DUI contains a unique name among all DUIs and a unique number among the DUIs within the DFI. All DUIs have at least one Data Item (DI) or field or attribute.

Database - An organized and integrated collection of stored operational data used by an Automated Data System.

Database Administrator - The person or group responsible for the design, creation, maintenance, and control of the database.

Database Management System - A software function providing data handling services to operators (end users), application programmers, and Database Administrators.

Entity - A real world object that is important to the system application.

Entity Instance - An occurrence of an entity.

Entity-Relationship Diagram - A diagram used in database design that illustrates entities and the associations among them.

File - The collection of records of a single type.

Foreign Key - An attribute that has a key of a different relation.

Functional Dependency - Relationship between X and Y such that, given a value of X, one can determine the value of Y. Written as $X \rightarrow Y$.

Hierarchical Data Model - A data model such that each record has exactly one parent, except the root, which has no parent.

Identifier - The attribute(s) and/or relationship(s) that uniquely identify a particular entity.

Interoperability - The ability of systems, units, or forces to provide services to, and accept services from other systems, units, or forces, and to use the services exchanged to enable them to operate effectively together.

Intraoperability - Interoperability among the Marine Corps systems.

Key - A group of one or more attributes that uniquely identifies a row (tuple, record)

Local Area Network - A collection of geographically close microcomputers that communicate.

Meta-data - Data about the structure of a database that is stored in the data dictionary.

Network Data Model - A data model in which all relationships are one-to-many and a child can have multiple parents as long as they are different record types.

Primary Key - An attribute or attribute group chosen as the key of a relation.

Protocol - Communication protocols are processes or sets of rules controlling the interchange of information.

Record - A group of related data items treated as a unit.

Record Type - Defines the structure of a record by identifying the names of the data elements present.

Record Occurrence - One particular instance of a record type with values assigned to the data elements.

Relation - A two-dimensional table containing single valued entries and no duplicate rows.

Relational Database - A database structured in accordance with the relational data model.

Relational Data Model - A data model in which data is stored in tables, and association between tables are represented within the table data.

Relationship - An association between two entities.

Schema - A logical view of a database.

Transitive Dependency - A relationship between attributes X, Y, and Z such that, if Y is determined by X, and Z is determined by Y, then Z is determined by X. Written as if $X \rightarrow Y$ and $Y \rightarrow Z$, then $X \rightarrow Z$.

Tuple - A row or record in a relation.

APPENDIX B: MILITARY ACRONYMS

AAW - Antiair Warfare
ACCS - Army Command and Control System
ACE - Aviation Combat Element
ASOC - Air Support Operations Center
ASR - Assault Support Request
ASRT - Air Support Radar Team
ATO - Air Tasking Order

BDA - Bomb Damage Assessment

CAS - Close Air Support
COC - Combat Operations Center
CP - Command Post or Control Point
CRLCMP - Computer Resources Life Cycle Management Plan
C2 - Command and Control
C2FAC - Command and Control Facility
C3I - Command, Control, Communication and Intelligence

DASC - Direct Air Support Center
DCT - Digital Communications Terminal
DFI - Data Field Identifier
DI - Data Item
DUI - Data Use Identifier

EMP - Electro-magnetic Pulse
EW/C - Early Warning/Control

FAC - Forward Air Controller
FAC(A) - Forward Air Controller (Airborne)
FMFM - Fleet Marine Field Manual
FRAGO - Fragmentation Operation Order
FSCC - Fire Support Coordination Center
FBC - Future Battle Cell

GCE - Ground Combat Element

HC(A) - Helicopter Coordinator (Airborne)

IDASC - Improved DASC (Facility)
ISEA - In-service Engineering Agent

JTAR - Joint Tactical Air Request

LAAD - Low Altitude Air Defense
LAAM - Light Antiaircraft Missile

MACCS - Maine Air Command and Control System

MACG - Marine Air Control Group
MAGTF - Marine Air-Ground Task Force
MATCS - Marine Air Traffic Control Squadron
MCASS - MTACCS Common Application Support Software
MCHS - MTACCS Common Hardware Suite
MCTSSA - Marine Corps Tactical System Support Activity
MMI - Man-machine Interface
MTACCS - Marine Corps Tactical Command and Control System
MTF - Message Text Format (also USMTF)
MTS - Marine Tactical Systems

NAVELEXCEN - Naval Electronics Systems Engineering Center
NDI - Non-developmental Item
NTACS - Naval Tactical Air Control System

ORD - Operational Requirements Document

PLRS - Position, Location, and Reporting System
P3I - Pre-planned Product Improvement

RAC - Refueling Area Coordinator
RIO - Report in/out
ROC - Required Operational Capability
RPV - Remotely Piloted Vehicle

SAAWC - Sector Antiair Warfare Coordinator
SAD - Senior Air Director

TAC - Tactical Air Commander
TAC(A) - Tactical Air Coordinator (Airborne)
TACC - Tactical Air Command Center (USMC)
TACP - Tactical Air Control Party
TACS - Tactical Air Control System (US Air Force)

TAOC - Tactical Air Operations Center

TAR - Tactical Air Request

TCO - Tactical Combat Operations

TDS - Tactical Data Systems

TIDP - Tactical Interface Design Plan

USMC - United States Marine Corps

APPENDIX C: DASC INFORMATION REQUIREMENTS

This appendix exhibits current DASC information requirements pertaining to the ATO database application. The messages, forms, and reports included are:

- the message text format Air Tasking Order
- the Joint Tactical Airstrike Request
- the Report-In/Out Log
- the Operational Summary Report

AIR TASKING ORDER

1. General

The Air Tasking Order/Confirmation message is computer readable and includes information based on the users needs. The message can include the following groups of information. If the group (set) is used the format is as follows:

SET NAME/FIELD 1/FIELD 2/.../FIELD N//

- Mandantory sets and fields are underlined. A field is mandandory only if that set is mandantory.
- Vetical lines with arrows show repeatable sets and nested segments.
- Capital letters means enter as is.

2. Message Map

EXER/exercise name/additional identifier//

OPER/operation name/plan originator and number/option name/second option name//

MSID/ATOCONF/originator/message serial number/month/qualifier/quailfier serial number//

REF/serial letter/(usmtf message short title) or (type of reference)/originator/date-time group/(msg ser number) or (doc ser number)/special notation/(sic) or (filing number)//

AMPN/free text to explain preceeding reference set//

NARR/free text to explain preceeding reference set//

CANX/serial letter/(usmtf message short title) or (type of reference)/originator/date-time group/(msg ser number) or (doc ser number)/special notation/(sic) or (filing number)//

PERID/time from/TO: time to/ASOF: as of time//

AIRTASK/air tasking/air tasking comments//

TASKUNIT/tasked unit designator/ICAO location/comments//

MSNDATA/mission number/package identification/aircraft call sign/number and type of aircraft/mission type/alert status/primary configuration code/secondary configuration code/iff-sif code and mode//

MSNLOC/mission start day-time/mission stop day-time/mission location name/(altitude) or (flight level)/air support request number/area coordinates//

TGTLOC/day-time on target/day-time off target/target identifier/target type/desired mean point of impact/air support request number/target comments//

RECDATA/request number/mission priority/day-time on target/latest time information of value/reconnaissance mission type/coverage type/imagery type/imagery code/coverage:mode/TGTCOD: reconnaissance target code/print scale/delivery address//

TRCPLOT/location of initial point/trace point location//

CONTROL/type of control/callsign/(primary frequency) or (primary frequency designator)/(secondary frequency) or secondary frequency designator/report-in point/control comments//

FACINFO/callsign/(primary frequency) or (primary frequency designator)/(secondary frequency) or secondary frequency designator/report-in point/support unit identity/control comments//

ELECMBT/aircraft callsign/priority/mission location/(altitude) or (flight level)/time on station/time off station/primary (frequency) or frequency designator/secondary (frequency) or frequency designator//

REFUEL/tanker call sign/tanker mission number/air refueling control point/(altitude) or (flight level)/air refueling control time/total offload of fuel/primary (frequency) or frequency designator/secondary (frequency) or frequency designator//

7REFUEL/mission number/aircraft call sign/number and type aircraft/total offload of fuel/air refueling control time/tanker assignment/refueling fuel type/reciever comments/

AKNLDG/acknowledgement instructions//

DECL/downgrading instructions//

JOINT TACTICAL AIRSTRIKE REQUEST

JOINT TACTICAL AIRSTRIKE REQUEST				See JCS Pub. Vol II, for instructions for preparation	
SECTION I - MISSION REQUEST				DATE	
1. UNIT CALLED		THIS IS		REQUEST NUMBER	
				SENT	
				TIME BY	
2. PREPLANNED <input type="checkbox"/> A PRECEDENCE <input type="checkbox"/> B PRIORITY <input type="checkbox"/> C				RECEIVED	
				TIME BY	
3. TARGET IS/NO OF					
<input type="checkbox"/> A PERS IN OPEN		<input type="checkbox"/> B PERS DUG IN		<input type="checkbox"/> C WPNS/MG/RVAT	
<input type="checkbox"/> D AAA ADA		<input type="checkbox"/> E AKTS MISSILE		<input type="checkbox"/> F ARMOR	
<input type="checkbox"/> G BLDGS		<input type="checkbox"/> H BRIDGES		<input type="checkbox"/> I PILLBOX, BUNKERS	
<input type="checkbox"/> J CENTER (CP, COM)		<input type="checkbox"/> K AREA		<input type="checkbox"/> L ROUTE	
<input type="checkbox"/> M REMARKS				<input type="checkbox"/> N MORTARS, ARTY	
				<input type="checkbox"/> O VEHICLES	
				<input type="checkbox"/> P SUPPLIES, EQUIP	
				<input type="checkbox"/> Q MOVING N E S W	
4. TARGET LOCATION IS				CHECKED	
<input type="checkbox"/> A (COORDINATES)		<input type="checkbox"/> B (COORDINATES)		<input type="checkbox"/> C (COORDINATES)	
<input type="checkbox"/> D (COORDINATES)		<input type="checkbox"/> E (COORDINATES)		<input type="checkbox"/> F (COORDINATES)	
<input type="checkbox"/> G TGT ELEV		<input type="checkbox"/> H SHEET NO		<input type="checkbox"/> I SERIES	
				<input type="checkbox"/> J CHART NO	
5. TARGET TIME/DATE					
<input type="checkbox"/> A ASAP		<input type="checkbox"/> B NLT		<input type="checkbox"/> C AT	
				<input type="checkbox"/> D TO	
6. DESIRED ORD/RESULTS					
<input type="checkbox"/> A ORDNANCE		<input type="checkbox"/> B DESTROY		<input type="checkbox"/> C NEUTRALIZE	
				<input type="checkbox"/> D HARASS/INTENDICT	
7. FINAL CONTROL					
<input type="checkbox"/> A FAC/RABFAC		<input type="checkbox"/> B CALL SIGN		<input type="checkbox"/> C FREQ	
<input type="checkbox"/> D ASRT		<input type="checkbox"/> E *FREQ		<input type="checkbox"/> F FIX/CONT PT	
8. REMARKS					
<input type="checkbox"/> A IP					
<input type="checkbox"/> B HDG _____ OFFSET L _____ R _____					
<input type="checkbox"/> C DIST _____ NM					
<input type="checkbox"/> D MARK TYPE _____ CODE _____					
<input type="checkbox"/> E FRIENDLIES					
<input type="checkbox"/> F EGRESS					
<input type="checkbox"/> G BCN TO TGT BRNG/BCN COORD _____ / _____					
<input type="checkbox"/> H BCN TO TGT RANGE/TGT COORD _____ / _____					
<input type="checkbox"/> I BCN ELEVATION _____ FT MSL					
SECTION II - COORDINATION					
9. NGF		10. ARTY		11. AIOG-2/G-3	
12. REQUEST		13. BY		14. REASON FOR DISAPPROVAL	
<input type="checkbox"/> APPROVED					
<input type="checkbox"/> DISAPPROVED					
15. RESTRICTIVE FIRE/AIR PLAN				16. IS IN EFFECT	
<input type="checkbox"/> A IS NOT		<input type="checkbox"/> B NUMBER		<input type="checkbox"/> C (FROM TIME) _____	
				<input type="checkbox"/> D (TO TIME) _____	
17. LOCATION				18. WIDTH (METERS)	
<input type="checkbox"/> A (FROM COORDINATES)		<input type="checkbox"/> B (TO COORDINATES)		<input type="checkbox"/> C (MAXIMUM/VERTEX) _____	
				<input type="checkbox"/> D (MINIMUM) _____	
SECTION III - MISSION DATA					
20. MISSION NUMBER		21. CALL SIGN		22. NO & TYPE AIRCRAFT	
24. EST/ACT TAKEOFF		25. EST TOT		26. CONT PT/RDNVS (COORD/NAVAID FIX)	
28. FAC/ASRT/TAC(A) CALL SIGN FREQ		29. RESTRICTIVE FIRE/AIR PLAN SEE 15 - 19		30. TGT DESCRIPTION	
				31. TGT COORD/ELEV	
32. BATTLE DAMAGE ASSESSMENT (BDA REPORT)					
<input type="checkbox"/> A TGT COORD _____					
<input type="checkbox"/> B TIME ON/OFF _____					
<input type="checkbox"/> C %ORD ON TGT/% TGT DESTROYED _____ / _____					
<input type="checkbox"/> D RESULTS _____					
<input type="checkbox"/> E UNIT SUPPORTED _____					
* TRANSMIT AS APPROPRIATE					

REPORT-IN/OUT LOGS

[illegible]

REPORTS
DIRECT AIR SUPPORT CENTER
OPERATIONAL SUMMARY

DATE: _____

FIXED WING	DAILY			MONTHLY			TOTAL		
NUMBER MISSIONS SCHEDULED									
NUMBER UNSCHEDULED MISSIONS FLOWN									
NUMBER OF MISSIONS CANX									
TOTAL NUMBER MISSIONS FLOWN									
TOTAL NUMBER OF A/C FLOWN									
NUMBER MISSIONS RIO'ED IN	P	C	T	C	P	T	C	P	T
NUMBER OF MISSIONS RIO'ED OUT									

REMARKS:

HELO	DAILY			MONTHLY			TOTAL		
NUMBER MISSIONS SCHEDULED									
NUMBER UNSCHEDULED MISSIONS FLOWN									
NUMBER OF MISSIONS CANX									
TOTAL NUMBER MISSIONS FLOWN									
TOTAL NUMBER OF A/C FLOWN									
NUMBER MISSIONS RIO'ED IN	P	C	T	C	P	T	C	P	T
NUMBER OF MISSIONS RIO'ED OUT									

REMARKS:

OPSUM (cont)

MEDEVAC	DAILY			MONTHLY			TOTAL		
	RC VD	CA NX	CO MP	RC VD	CA NX	CO MP	RC VD	CA NX	C O M P
ACTUAL									
SIMULATED									

REMARKS:

JTAR	DAILY			MONTHLY			TOTAL		
	RC VD	CA NX	CO MP	RC VD	CA NX	CO MP	RC VD	CA NX	C O M P
ACTUAL									
SIMULATED									

REMARKS:

ASR	DAILY			MONTHLY			TOTAL		
	RC VD	CA NX	CO MP	RC VD	CA NX	CO MP	RC VD	CA NX	C O M P
ACTUAL									
SIMULATED									

REMARKS:

	DAILY			MONTHLY			TOTAL		
TOTAL OPERATIONAL HOURS									

REMARKS:

APPENDIX D: ENTITY-RELATIONSHIP SPECIFICATIONS

This appendix lists and explains the information depicted on the Entity-Relationship diagram, Figure 8. It includes:

- attribute names, abbreviations, formats, and keys
- entities and relationship attribute listing
- cardinality connections and rules

ENTITY-RELATIONSHIP ATTRIBUTES

<u>Attribute Name</u>	<u>Abbreviation</u>	<u>Format</u>	<u>Key</u>	<u>Abbrev</u>
A/C_CALLSIGN	C/S	C,12	Y Y	ATO_MSN REFULEE
Comm: A/C callsign				
ACTUAL TIME OF ARRIVAL	ATA	N,4	N	RIO_LOGS
Comm: Actual time A/C reported in with DASC				
ACTUAL TIME OF RETURN	ATR	N,4	N	RIO_LOGS
Comm: Actual time A/C reported out with DASC				
AIRCRAFT_TYPE	TYPE	C,6	N N	ATO_MSN REFULEE
Comm: Aircraft/helicopter type/model/category (entry list 513)				
AIR TASKING CODE	ATO_CODE	C,43	Y	ATO
Comm: Code for air tasking type (entry list 2005)				
ALERT STATUS	ALR	C,3	N	ATO_MSN
Comm: Alert status code (Annex 33 CH 3/USMTF)				
ALTITUDE	ALT	C,5	N	MSNLOC
Comm: A/C altitude (Annex 2 CH 3/USMTF)				
AMOUNT OF FUEL	LBSFUEL	N,4	N	REFULEE
Comm: Amount of fuel allowed per aircraft in hundreds of lbs				
ARRIVAL TIME	ATIME	C,7	N	ROUTE
Comm: Arrival time (Annex 2 CH 3/USMTF)				
ATO_START	ATO_START	C,7	Y	ATO
Comm: Day, hour, minute, time zone of ATO Start				
ATO_STOP	ATO_STOP	C,7	Y	ATO
Comm: Day, hour, minute, time zone of ATO stop				
BDA COMMENT	BDACMNT	C,30	N	BDA
Comm: Description of results				
CALLSIGN	CALLSIGN	C,15	Y	CONTROL
Comm: Control agency's callsign				

CONTROL AGENCY	CONT	C,4	N	CONTROL
Comm: Code for the control agency type from the event list				
CONTROL POINT	RIO_CP	C,20	N	CONTROL
Comm: Location the A/C is to check in with the control agency				
CONTROL POINT TYPE	CPTY2	C,3	N	ROUTE
Comm: Code for the route point type (Annex 2 CH 3/USMTF)				
COVERAGE TYPE	COVERAGE	C,7	N	RECDATA
Comm: Code for type of coverage (Annex 34 CH 3/USMTF)				
EST TIME AIRBORNE	ETA	N,4	N	A/C STATUS
Comm: Estimated time A/C airborne				
EST TIME OF RETURN	ETR	N,4	N	A/C STATUS
Comm: Estimate time A/C returns				
FUEL REQUIREMENTS	FUREQ	N,4	N	REFULEE
Comm: Total amount of fuel req for the msn in hundreds of lbs				
IFF/SIF CODES	IFFCODE	C,5	N	ATO MSN
Comm: IFF/SIF mode and code (1x (mode), 2-4N (code))				
IMMEDIATE AIR REQUEST NUMBER IMMEDIATE		C,5	Y	IMED AIR
Comm: JTAR, ASR, MEDEVAC Request Number				
LATEST TIME INFO OF VALUE LTIOV		C,11	N	RECDATA
Comm: Latest time in year, month, day, hour, min, time zone				
LOCATION	LOCN	C,20	Y	BDA
			N	MSNLOC
			Y	RECTGT
			N	ROUTE
			N	TGTLOC
Comm: Mission location (entry list 11)				
LOCATION TYPE	LOCTYP	C,6	N	MSNLOC
Comm: Code for a mission location (Annex 2 CH 3/USMTF)				
MISSION COMMENT	MSNCMNT	C,22	N	MSNLOC
Comm: Comments on the mission location				
MISSION NUMBER	MSNNO	C,8	Y	ATO MSN
			Y	REFULEE
			Y	RIO LOGS
Comm: Mission No. (date, fixed/helo, sequence (25H-0009))				
MISSION START	MSTART	C,7	N	RECDATA
Comm: Time on target				

MISSION_TYPE	MSN	C, 5	N	ATO_MSN
Comm: Mission type (entry list 107A)			N	RECDATA
NUMBER_OF_AIRCRAFT	NO	C, 3	N	REFULEE
Comm: Number of aircraft			N	ATO_MSN
PERCENT_ORDNANCE_ON_TARGET	ORD_ON_TGT	N, 2	N	BDA
Comm: Percentage of Ordnance hitting target				
PERCENT_TARGET_DESTROYED	TGT_DESTROYED	N, 2	N	BDA
Comm: Percentage of target destroyed				
POINT_NUMBER	PN	N, 2	Y	ROUTE
Comm: Numeric sequence given to the reference point (1-99)				
PRIMARY_CONFIGURATION_CODE	PRICONFIG	C, 5	N	ATO_MSN
Comm: Primary configuration code for the aircraft				
PRIMARY_FREQUENCY	PRIFREQ	C, 8	N	CONTROL
Comm: Frequency in megahertz, or the frequency designator (blue)				
PRIORITY	PR	C, 1	N	RECDATA
Comm: Priority for the mission				
REFUELING_TIME	RFLTIME	C, 7	N	REFULEE
Comm: Refueling time in day, hour, minute, time zone				
REQUEST_NUMBER	REQNO	C, 6	Y	MSNLOC
			Y	RECDATA
Comm: Preplanned Air Support Request Number				
SECONDARY_CONFIGURATION_CODE	SECCONFIG	C, 5	N	ATO_MSN
Comm: Secondary configuration code for the aircraft				
SECONDARY_FREQUENCY	SECFRQ	C, 8	N	CONTROL
Comm: Frequency in megahertz, or by frequency designator (blue)				
TARGET_COMMENTS	TGTCMNT	C, 35	N	TGTLOC
Comm: Comments describing the target				
TARGET_IDENTIFIER	TGTID	C, 20	Y	TGTLOC
Comm: Assigned Target Number or Name (entry list II, table II)				
TARGET_LENGTH	TLGTH	C, 7	N	RECTGT
Comm: Estimated target length (Annex 2 CH 3/USMTF)				
TARGET_TYPE	TGTTYP	C, 6	N	TGTLOC
Comm: Target type (entry list 20)				

TARGET WIDTH	TWDRAD	C,7	N	RECTGT
Comm: Estimated width or radius (Annex 2 CH 3/USMTF)				
TIME-OFF-TARGET	TFT	C,7	Y	BDA
Comm: Time off target (day, hour, minute, time zone)				
TIME-OFF-TARGET	TFT	C,7	N	TGTLOC
Comm: Time off target (day, hour, minute, time zone)				
TIME-ON-TARGET	TOT	C,7	Y	BDA
			N	TGTLOC
Comm: Time on target (day, hour, minute, time zone)				
UNIT_SUPPORTED	SUPPORTED	C,9	N	IMED AIR
			N	BDA
Comm: Unit supported by Immediate Air Request				

ENTITY AND RELATIONSHIP REPORT

AIR_TASKING_ORDER

Relation Type - Entity

List of Attributes (fields):

	Name	Abbreviation	Format	Key
1.	ATO_START	ATO_START	C,7	Y
	Day, hour, minute, time zone of ATO Start			
2.	ATO_STOP	ATO_STOP	C,7	Y
	Day, hour, minute, time zone of ATO stop			
3.	AIR_TASKING_CODE	ATO_CODE	C,43	Y
	Code for air tasking type (entry list 2005)			

ASSESSES

Relation Type - Relationship

Remark: BDAs may be reported on a target

List of Attributes (fields): NONE

BATTLE_DAMAGE_ASSESSMENT

Relation Type - Entity

List of Attributes (fields):

	Name	Abbreviation	Format	Key
1.	LOCATION	LOCN	C,20	Y
	Mission location (entry list 11)			
2.	TIME-ON-TARGET	TOT	C,7	Y
	Time on target (day, hour, minute, time zone)			
3.	TIME-OFF-TARGET	TFT	C,7	Y
	Time off target (day, hour, minute, time zone)			
4.	PERCENT_ORDNANCE_ON_TARGET	ORD_ON_TGT	N,2	N
	Percentage of Ordnance hitting target			
5.	PERCENT_TARGET_DESTROYED	TGT_DESTROYED	N,2	N
	Percentage of target destroyed			
6.	BDA_COMMENT	BDACMNT	C,30	N
	Description of results			
7.	UNIT_SUPPORTED	SUPPORTED	C,9	N

COMPRISES

Relation Type - Relationship

Remark: ATO is comprised of various missions

List of Attributes (fields): NONE

CONTROLS

Relation Type - Relationship

Remark: A/C Mission is controlled by various controlling agencies

List of Attributes (fields): NONE

CONTROL_AGENCY

Relation Type - Entity

List of Attributes (fields):

	Name	Abbreviation	Format	Key
1.	CALLSIGN	CALLSIGN	C,15	Y
	Control agency's callsign			
2.	CONTROL_AGENCY	CONT	C,4	N
	Code for the control agency type from the event list			
3.	PRIMARY_FREQUENCY	PRIFREQ	C,8	N
	Frequency in megahertz, or the frequency designator (blue)			
4.	SECONDARY_FREQUENCY	SECFRQ	C,8	N
	Frequency in megahertz, or by frequency designator (blue)			
5.	CONTROL_POINT	RIO_CP	C,20	N
	Location the A/C is to check in with the control agency			

IMMEDIATE_REQUESTS

Relation Type - Entity

List of Attributes (fields):

	Name	Abbreviation	Format	Key
1.	IMMEDIATE AIR REQUEST NUMBER	IMMEDIATE	C,5	Y
	JTAR, ASR, MEDEVAC Request Number			
2.	UNIT_SUPPORTED	SUPPORTED	C,9	N
	Unit supported by Immediate Air Request			

INTEREST_IN

Relation Type - Relationship

Remark: Recon MSN interested in Recon Target Data

List of Attributes (fields): NONE

MAY_DESIGNATE

Relation Type - Relationship

Remark: Entity Route if the Mission is to follow a certain route

List of Attributes (fields): NONE

MISSION (ATO MISSION)		Relation Type - Entity	
List of Attributes (fields):			
Name	Abbreviation	Format	Key
1. MISSION_NUMBER Mission No. (date, fixed/helo, sequence (25H-0009))	MSNNO	C,8	Y
2. A/CCALLSIGN A/C callsign	C/S	C,12	Y
3. NUMBER_OF_AIRCRAFT Number of Aircraft	NO	C,2	N
4. AIRCRAFT_TYPE Aircraft/helicopter type/model/category (entry list 513)	TYPE	C,6	N
5. MISSION_TYPE Mission type (entry list 107A)	MSN	C,5	N
6. ALERT_STATUS Alert status code (Annex 33 CH 3/USMTF)	ALR	C,3	N
7. PRIMARY_CONFIGURATION_CODE Primary configuration code for the aircraft	PRICONFIG	C,5	N
8. SECONDARY_CONFIGURATION_CODE Secondary configuration code for the aircraft	SECCONFIG	C,5	N
9. IFF/SIF_CODES IFF/SIF mode and code (1x (mode), 2-4N (code))	IFFCODE	C,5	N
10. EST_TIME_AIRBORNE Estimated time A/C airborne	ETA	N,4	N
11. EST_TIME_OF_RETURN Estimated time A/C returns	ETR	N,4	N

MISSION LOCATION		Relation Type- Entity	
List of Attributes (fields):			
Name	Abbreviation	Format	Key
1. REQUEST_NUMBER Preplanned Air Support Request Number	REQNO	C,6	Y
2. LOCATION_TYPE Code for a mission location (Annex 2 CH 3/USMTF)	LOCTYP	C,6	N
3. LOCATION Mission location (entry list 11)	LOCN	C,20	N
4. ALTITUDE A/C altitude (Annex 2 CH 3/USMTF)	ALT	C,5	N
5. MISSION_COMMENT Comments on the mission location	MSNCMNT	C,22	N

RECEIVING_AIRCRAFT**Relation Type - Entity****List of Attributes (fields):**

	Name	Abbreviation	Format	Key
1.	MISSION_NUMBER	MSNNO	C,8	Y
	Mission No. (date, fixed/helo, sequence (25H-0009))			
2.	A/CCALLSIGN	C/S	C,12	Y
	A/C callsign			
3.	NUMBER_OF_AIRCRAFT	NO	C,3	N
	Number of aircraft			
4.	AIRCRAFT_TYPE	TYPE	C,6	N
	Aircraft/helicopter type/model/category (entry list 513)			
5.	AMOUNT_OF_FUEL	LBSFUEL	N,4	N
	Amount of fuel allowed per aircraft in hundreds of lbs			
6.	FUEL_REQUIREMENTS	FUREQ	N,4	N
	Total amount of fuel req for the msn in hundreds of lbs			
7.	REFUELING_TIME	RFLTIME	C,7	N
	Refueling time in day, hour, minute, time zone			

RECONNAISSANCE**Relation Type - Entity****List of Attributes (fields):**

	Name	Abbreviation	Format	Key
1.	REQUEST_NUMBER	REQNO	C,6	Y
	Preplanned Air Support Request Number			
2.	PRIORITY	PR	C,1	N
	Priority for the mission			
3.	MISSION_START	MSTART	C,7	N
	Time on target			
4.	LATEST_TIME_INFO_OF_VALUE	LTIOV	C,11	N
	Latest time in year, month, day, hour, min, time zone			
5.	MISSION_TYPE	MSN	C,5	N
	Mission type (entry list 107A)			
6.	COVERAGE_TYPE	COVERAGE	C,7	N
	Code for type of coverage (Annex 34 CH 3/USMTF)			

RECON_TARGET**Relation Type - Entity****List of Attributes (fields):**

	Name	Abbreviation	Format	Key
1.	LOCATION	LOCN	C,20	Y
	Mission location (entry list 11)			
2.	TARGET_LENGTH	TLGTH	C,7	N
	Estimated target length (Annex 2 CH 3/USMTF)			
3.	TARGET_WIDTH	TWDRAD	C,7	N
	Estimated width or radius (Annex 2 CH 3/USMTF)			

REFUELS**Relation Type - Relationship**

Remark: Refueling Mission Refuels Receiving Aircraft

List of Attributes (fields): NONE

REQUESTS

Relation Type - Relationship

Remark: Immediate air support requests Mission from ATO to perform List of Attributes (fields):
NONE

RIO_LOGS

Relation Type - Entity

List of Attributes (fields):

	Name	Abbreviation	Format	Key
1.	MISSION_NUMBER	MSNNO	C,8	Y
	Mission No. (date, fixed/helo, sequence (25H-0009))			
2.	ACTUAL_TIME_OF_ARRIVAL	ATA	N,4	N
	Actual time A/C reported in with DASC			
3.	ACTUAL_TIME_OF_RETURN	ATR	N,4	N
	Actual time A/C reported out with DASC			

ROUTE

Relation Type - Entity

List of Attributes (fields):

	Name	Abbreviation	Format	Key
1.	POINT_NUMBER	PN	N,2	Y
	Numeric sequence given to the reference point (1-99)			
2.	CONTROL_POINT_TYPE	CPTYP	C,3	N
	Code for the route point type (Annex 2 CH 3/USMTF)			
3.	LOCATION	LOCN	C,20	N
	Mission location (entry list II)			
4.	ARRIVAL_TIME	ATIME	C,7	N
	Arrival time (Annex 2 CH 3/USMTF)			

TARGET_LOCATION

Relation Type - Entity

List of Attributes (fields):

	Name	Abbreviation	Format	Key
1.	TARGET_IDENTIFIER	TGTID	C,20	Y
	Assigned Target Number or Name (entry list 11, table II)			
2.	TIME-ON-TARGET	TOT	C,7	N
	Time on target (day, hour, minute, time zone)			
3.	TIME-OFF-TARGET	TFT	C,7	N
	Time off target (day, hour, minute, time zone)			
4.	TARGET_TYPE	TGTTYP	C,6	N
	Target type (entry list 20)			
5.	LOCATION	LOCN	C,20	N
	Mission location (entry list II)			
6.	TARGET_COMMENTS	TGTCMNT	C,35	N
	Comments describing the target			

UPDATES

Relation Type - Relationship

Remark: TAD/HD logs append/update ATO with actual data List

List of Attributes (fields): NONE

CARDINALITY and CELL LINKS REPORT

Connections Listing by Cell

Entity AIR_TASKING_ORDER	abbrev: ATO
to Entity MISSION	abbrev: ATO_MSN
through Relationship COMPRISES	abbrev: COMP

CARDINALITY	CARDINALITY
lower = 1	lower = 1
upper = 1	upper = N
lower n = 1	lower n = 1
upper n = 1	upper n =

Entity AIR_TASKING_ORDER	abbrev: ATO
to Entity RIO_LOGS	abbrev: RIO_LOGS
through Relationship UPDATES	abbrev: UPDATES

CARDINALITY	CARDINALITY
lower = 1	lower = 1
upper = 1	upper = N
lower n = 1	lower n = 1
upper n = 1	upper n =

Entity MISSION	abbrev: ATO MSN
to Entity IMMEDIATE_REQUESTS	abbrev: IMED AIR
through Relationship REQUESTS	abbrev: REQUESTS

CARDINALITY	CARDINALITY
lower = 1	lower = 0
upper = N	upper = N
lower n = 1	lower n = 0
upper n =	upper n =

Entity MISSION	abbrev: ATO MSN
parent of Entity RECONNAISSANCE	abbrev: RECDATA
through ISA RELATIONSHIP MISSION	abbrev: ATO MSN

CARDINALITY	CARDINALITY
lower = 1	lower = 0
upper = 1	upper = N
lower n = 1	lower n = 0
upper n = 1	upper n =

Entity MISSION	abbrev: ATO MSN
parent of Entity MISSION_LOCATION	abbrev: MSNLOC
through ISA RELATIONSHIP MISSION	abbrev: ATO MSN

CARDINALITY	CARDINALITY
lower = 1	lower = 0
upper = 1	upper = N
lower n = 1	lower n = 0
upper n = 1	upper n =

Entity MISSION	abbrev: ATO_MS
to Entity AIR_TASKING_ORDER	abbrev: ATO
through Relationship COMPRISES	abbrev: COMP

CARDINALITY	CARDINALITY
lower = 1	lower = 1
upper = N	upper = 1
lower n = 1	lower n = 1
upper n =	upper n = 1

Entity MISSION	abbrev: ATO_MS
to Entity ROUTE	abbrev: ROUTE
through Relationship MAY_DESIGNATE	abbrev: DESIGNAT

CARDINALITY	CARDINALITY
lower = 1	lower = 0
upper = 1	upper = N
lower n = 1	lower n = 0
upper n = 1	upper n =

Entity MISSION	abbrev: ATO MSN
parent of Entity TARGET_LOCATION	abbrev: TGTLOC
through ISA RELATIONSHIP MISSION	abbrev: ATO MSN

CARDINALITY	CARDINALITY
lower = 1	lower = 0
upper = 1	upper = N
lower n = 1	lower n = 0
upper n = 1	upper n =

Entity MISSION	abbrev: ATO_MSN
to Entity CONTROL_AGENCY	abbrev: CONTROL
through Relationship CONTROLS	abbrev: CONTROLS

CARDINALITY	CARDINALITY
lower = 1	lower = 0
upper = 1	upper = N
lower n = 1	lower n = 0
upper n = 1	upper n =

Entity BATTLE_DAMAGE_ASSESSMENT	abbrev: BDA
to Entity TARGET_LOCATION	abbrev: TGTLOC
through Relationship ASSESSES	abbrev: ASSESSES

CARDINALITY	CARDINALITY
lower = 0	lower = 1
upper = N	upper = 1
lower n = 0	lower n = 1
upper n =	upper n = 1

Entity CONTROL_AGENCY	abbrev: CONTROL
to Entity MISSION	abbrev: ATO_MSN
through Relationship CONTROLS	abbrev: CONTROLS

CARDINALITY	CARDINALITY
lower = 0	lower = 1
upper = N	upper = 1
lower n = 0	lower n = 1
upper n =	upper n = 1

Entity IMMEDIATE_REQUESTS	abbrev: IMED AIR
to Entity MISSION	abbrev: ATO_MSN
through Relationship REQUESTS	abbrev: REQUESTS

CARDINALITY	CARDINALITY
lower = 0	lower = 1
upper = N	upper = N
lower n = 0	lower n = 1
upper n =	upper n =

Entity MISSION_LOCATION	abbrev: MSNLOC
to Entity RECEIVING_AIRCRAFT	abbrev: REFULEE
through Relationship REFUELS	abbrev: REFUELS

CARDINALITY	CARDINALITY
lower = 1	lower = 0
upper = 1	upper = N
lower n = 1	lower n = 0
upper n = 1	upper n =

Entity MISSION_LOCATION	abbrev: MSNLOC
child of Entity MISSION	abbrev: ATO_MSN
through ISA RELATIONSHIP MISSION	abbrev: ATO_MSN

CARDINALITY	CARDINALITY
lower = 0	lower = 1
upper = N	upper = 1
lower n = 0	lower n = 1
upper n =	upper n = 1

Entity RECONNAISSANCE	abbrev: RECDATA
to Entity RECON_TARGET	abbrev: RECTGT
through Relationship INTEREST_IN	abbrev: INT

CARDINALITY	CARDINALITY
lower = 1	lower = 1
upper = N	upper = N
lower n = 1	lower n = 1
upper n =	upper n =

Entity RECONNAISSANCE abbrev: RECDATA
child of Entity MISSION abbrev: ATO MSN
through ISA RELATIONSHIP MISSION abbrev: ATO_MSN

CARDINALITY	CARDINALITY
lower = 0	lower = 1
upper = N	upper = 1
lower n = 0	lower n = 1
upper n =	upper n = 1

Entity RECON TARGET abbrev: RECTGT
to Entity RECONNAISSANCE abbrev: RECDATA
through Relationship INTEREST_IN abbrev: INT

CARDINALITY	CARDINALITY
lower = 1	lower = 1
upper = N	upper = N
lower n = 1	lower n = 1
upper n =	upper n =

Entity RECEIVING_AIRCRAFT abbrev: REFULEE
to Entity MISSION_LOCATION abbrev: MSNLOC
through Relationship REFUELS abbrev: REFUELS

CARDINALITY	CARDINALITY
lower = 0	lower = 1
upper = N	upper = 1
lower n = 0	lower n = 1
upper n =	upper n = 1

Entity RIOLOGS abbrev: RIO_LOGS
to Entity AIR_TASKING_ORDER abbrev: ATO
through Relationship UPDATES abbrev: UPDATES

CARDINALITY	CARDINALITY
lower = 1	lower = 1
upper = N	upper = 1
lower n = 1	lower n = 1
upper n =	upper n = 1

Entity ROUTE	abbrev: ROUTE
to Entity MISSION	abbrev: ATO_MSN
through Relationship MAY_DESIGNATE	abbrev: DESIGNAT

CARDINALITY	CARDINALITY
lower = 0	lower = 1
upper = N	upper = 1
lower n = 0	lower n = 1
upper n =	upper n = 1

Entity TARGET_LOCATION	abbrev: TGTLOC
child of Entity MISSION	abbrev: ATO_MSN
through ISA RELATIONSHIP MISSION	abbrev: ATO_MSN

CARDINALITY	CARDINALITY
lower = 0	lower = 1
upper = N	upper = 1
lower n = 0	lower n = 1
upper n =	upper n = 1

Entity TARGET_LOCATION	abbrev: TGTLOC
to Entity BATTLE_DAMAGE_ASSESSMENT	abbrev: BDA
through Relationship ASSESSES	abbrev: ASSESSES

CARDINALITY	CARDINALITY
lower = 1	lower = 0
upper = 1	upper = N
lower n = 1	lower n = 0
upper n = 1	upper n =

ISA RELATIONSHIP MISSION's	abbrev: ATO_MSN
parent is Entity MISSION	abbrev: ATO_MSN

ISA RELATIONSHIP MISSION's	abbrev: ATO_MSN
child is Entity TARGET_LOCATION	abbrev: TGTLOC

ISA RELATIONSHIP MISSION's	abbrev: ATO_MSN
child is Entity MISSION_LOCATION	abbrev: MSNLOC

abbrev: ATO_MSN
abbrev: ATO_MSN

abbrev: ATO_MSN
abbrev: RECDATA

abbrev: ATO_MSN
abbrev: ATO_MSN

abbrev: ASSESSES
abbrev: TGTLOC

```
lower = 1
upper = 1
lower n = 1
upper n = 1
```

abbrev: ASSESSES
MENT abbrev: BDA

```
lower = 0
upper = N
lower n = 0
upper n =
```

abbrev: COMP
abbrev: ATO

```
lower = 1
upper = 1
lower n = 1
upper n = 1
```

Relationship COMPRISES
to Entity MISSION

abbrev: COMP
abbrev: ATO_MSN

CARDINALITY

lower = 1
upper = N
lower n = 1
upper n =

Relationship CONTROLS
to Entity MISSION

abbrev: CONTROLS
abbrev: ATO_MSN

CARDINALITY

lower = 1
upper = 1
lower n = 1
upper n = 1

Relationship CONTROLS
to Entity CONTROL_AGENCY

abbrev: CONTROLS
abbrev: CONTROL

CARDINALITY

lower = 0
upper = N
lower n = 0
upper n =

Relationship MAY-DESIGNATE
to Entity MISSION

abbrev: DESIGNAT
abbrev: ATO_MSN

CARDINALITY

lower = 1
upper = 1
lower n = 1
upper n = 1

Relationship MAY_DESIGNATE
to Entity ROUTE

abbrev: DESIGNAT
abbrev: ROUTE

CARDINALITY

lower = 0
upper = N
lower n = 0
upper n =

Relationship INTEREST_IN
to Entity RECON_TARGET

abbrev: INT
abbrev: RECTGT

CARDINALITY

lower = 1
upper = N
lower n = 1
upper n =

Relationship INTEREST_IN
to Entity RECONNAISSANCE

abbrev: INT
abbrev: RECDATA

CARDINALITY

lower = 1
upper = N
lower n = 1
upper n =

Relationship REFUELS
to Entity RECEIVING_AIRCRAFT

abbrev: REFUELS
abbrev: REFULEE

CARDINALITY

lower = 0
upper = N
lower n = 0
upper n =

Relationship REFUELS
to Entity MISSION_LOCATION

abbrev: REFUELS
abbrev: MSNLOC

CARDINALITY

lower = 1
upper = 1
lower n = 1
upper n = 1

Relationship REQUESTS
to Entity IMMEDIATE_REQUESTS

abbrev: REQUESTS
abbrev: IMED AIR

CARDINALITY

lower = 0
upper = N
lower n = 0
upper n =

Relationship REQUESTS
to Entity MISSION

abbrev: REQUESTS
abbrev: ATO_MSN

CARDINALITY

lower = 1
upper = N
lower n = 1
upper n =

Relationship UPDATES
to Entity AIR_TASKING_ORDER

abbrev: UPDATES
abbrev: ATO

CARDINALITY

lower = 1
upper = 1
lower n = 1
upper n = 1

Relationship UPDATES
to Entity RIO_LOGS

abbrev: UPDATES
abbrev: RIO_LOGS

CARDINALITY

lower = 1

upper = N

lower n = 1

upper n =

APPENDIX E: E-R DESIGNER RELATIONAL SCHEMA

CONTROL_AGENCY (*callsign* : control_agency, primary_frequency, secondary_frequency, control_point)

AIR_TASKING_ORDER (*ato_start*, *ato_stop*, *air_tasking_code* :)

ROUTE (*mission_number*, *point_number* : control_point_type, location, arrival_time)

RIO_LOGS (*mission_number* : actual_time_of_arrival, actual_time_of_return)

RECEIVING_AIRCRAFT (*mission_number*, *alc_callsign* : number_of_aircraft, aircraft_type, amount_of_fuel, fuel_requirements, refueling_time)

BATTLE_DAMAGE_ASSESSMENT (*location*, *time-on-target* : time-off-target, percent_ordnance_on_target, percent_target_destroyed, bda_comment, unit_supported)

MISSION_LOCATION (*request_number*, *mission_number*, *alc_callsign* : location_type, location, altitude, mission_comment)

MISSION (*mission_number*, *alc_callsign*, *request number* : number_of_aircraft, aircraft_type, mission_type, alert_status, primary_configuration_code, secondary_configuration_code, iff/sif_codes, est_time_airborne, est_time_of_return)

TARGET_LOCATION (*target_identifier*, *mission_number*, *alc_callsign*, *request_number* : time-on-target, time-off-target, target_type, location, target_comments)

RECONNAISSANCE (*request_number* : priority, mission_start, mission_stop, latest_time_info_of_value, mission_type, coverage_type)

IMMEDIATE_REQUESTS (*immediate_air_request_number* : unit_supported)

RECON_TARGET (*location* : target_length, target_width)

-----Key-----

RELATION (*primary key attribute(s)* : non-key attribute(s))

COMPRISES (*ato_start, ato_stop, air_tasking_code, mission_number, a/c_callsign* :)

ASSESSES (*target_identifier, location, time-on-target, time-off-target* :)

CONTROLS (*mission_number, a/c_callsign, callsign* :)

REQUESTS (*immediate_air_request_number, mission_number, a/c_callsign* :)

INTEREST_IN (*location, request_number* :)

MAY_DESIGNATE (*mission_number, a/c_callsign, point_number* :)

UPDATES (*ato_start, ato_stop, air_tasking_code, mission_number* :)

REFUELS (*mission_number, a/c_callsign, request_number* :)

E-R Designer Relational Schema File Format

CONTROL_AGENCY	5	1	
CALLSIGN			C,15
CONTROL_AGENCY			C,4
PRIMARY_FREQUENCY			C,8
SECONDARY_FREQUENCY			C,8
CONTROL_POINT			C,20

AIR_TASKING_ORDER	3	3	
ATO_START			C,7
ATO_STOP			C,7
AIR_TASKING_CODE			C,43

ROUTE	5	2	
MISSION_NUMBER			C,8
POINT_NUMBER			N,2
CONTROL_POINT_TYPE			C,3
LOCATION			C,20
ARRIVAL_TIME			C,7

RIO_LOGS	3	1	
MISSION_NUMBER			C,8
ACTUAL_TIME_OF_ARRIVAL			N,4
ACTUAL_TIME_OF_RETURN			N,4

RECEIVING_AIRCRAFT	7	2	
MISSION_NUMBER			C,8
A/C_CALLSIGN			C,12
NUMBER_OF_AIRCRAFT			N,2
AIRCRAFT_TYPE			C,6
AMOUNT_OF_FUEL			N,4
FUEL_REQUIREMENTS			N,4
REFUELING_TIME			C,7

-----Key-----

Relation	# of attributes, # of primary key attributes
Attribute	field format, max length
	C (character)
	N (numeric)

BATTLE_DAMAGE_ASSESSMENT 7 3	
LOCATION	C,20
TIME-ON-TARGET	C,7
TIME-OFF-TARGET	C,7
PERCENT_ORDNANCE_ON_TARGET	N,2
PERCENT_TARGET_DESTROYED	N,2
BDA_COMMENT	C,30
UNIT_SUPPORTED	C,9

MISSION_LOCATION 7 3	
REQUEST_NUMBER	C,6
MISSION_NUMBER	C,8
A/C_CALLSIGN	C,12
LOCATION_TYPE	C,6
LOCATION	C,20
ALTITUDE	C,5
MISSION_COMMENT	C,22

MISSION 13 3	
MISSION_NUMBER	C,8
A/C_CALLSIGN	C,12
REQUEST NUMBER	C,6
NUMBER_OF_AIRCRAFT	C,2
AIRCRAFT_TYPE	C,6
MISSION_TYPE	C,5
ALERT_STATUS	C,3
PRIMARY_CONFIGURATION_CODE	C,5
SECONDARY_CONFIGURATION_CODE	C,5
IFF/SIF_CODES	C,5
EST_TIME_AIRBORNE	N,4
EST_TIME_OF_RETURN	N,4

TARGET_LOCATION 9 4	
TARGET_IDENTIFIER	C,20
MISSION_NUMBER	C,8
A/C_CALLSIGN	C,12
REQUEST_NUMBER	C,6
TIME-ON-TARGET	C,7
TIME-OFF-TARGET	C,7
TARGET_TYPE	C,6
LOCATION	C,20
TARGET_COMMENTS	C,35

RECONNAISSANCE 7 1	
REQUEST_NUMBER	C,6
PRIORITY	C,1
MISSION_START	C,7
MISSION_STOP	C,7
LATEST_TIME_INFO_OF_VALUE	C,11
MISSION_TYPE	C,5
COVERAGE_TYPE	C,7
IMMEDIATE_REQUESTS 2 1	
IMMEDIATE_AIR_REQUEST_NUMBER	C,5
UNIT_SUPPORTED	C,9
RECON_TARGET 3 1	
LOCATION	C,20
TARGET_LENGTH	C,7
TARGET_WIDTH	C,7
COMPRISES 5 5	
ATO_START	C,7
ATO_STOP	C,7
AIR_TASKING_CODE	C,43
MISSION_NUMBER	C,8
A/C_CALLSIGN	C,12
ASSESSES 4 4	
TARGET_IDENTIFIER	C,20
LOCATION	C,20
TIME-ON-TARGET	C,7
TIME-OFF-TARGET	C,7
CONTROLS 3 3	
MISSION_NUMBER	C,8
A/C_CALLSIGN	C,12
CALLSIGN	C,15
REQUESTS 3 3	
IMMEDIATE_AIR_REQUEST_NUMBER	C,5
MISSION_NUMBER	C,8
A/C_CALLSIGN	C,12

INTEREST_IN 2 2	
LOCATION	C,20
REQUEST_NUMBER	C,6
MAY_DESIGNATE 3 3	
MISSION_NUMBER	C,8
A/C_CALLSIGN	C,12
POINT_NUMBER	N,2
UPDATES 4 4	
ATO_START	C,7
ATO_STOP	C,7
AIR_TASKING_CODE	C,43
MISSION_NUMBER	C,8
REFUELS 3 3	
MISSION_NUMBER	C,8
A/C_CALLSIGN	C,12
REQUEST_NUMBER	C,6

APPENDIX F: NORMALIZER LOG

ENTERING FD FOR THE RELATION: CONTROL_AGENCY

CONTROL_AGENCY (CALLSIGN, CONTROL_AGENCY, PRIMARY_FREQUENCY,
SECONDARY_FREQUENCY, CONTROL_POINT)

Candidate keys=

1 CALLSIGN

All Fd's entered for this relation

1: CALLSIGN ---> CONTROL_AGENCY PRIMARY_FREQUENCY
SECONDARY_FREQUENCY

2: CONTROL_AGENCY ---> CONTROL_POINT

RESULT OF CHECKING NORMAL FORMS FOR RELATION (CONTROL_AGENCY)

NOTATION: Y : SATISFACTORY N : NOT SATISFACTORY

FD no. BCNF 3NF

1 Y Y

2 N N

Removing the EXTRANEIOUS ATTRIBUTES begins.....

No extraneous attribute found

SEARCHING for REDUNDANT FDs begins.....

NO redundant FD found.

CONSTRUCTION OF RELATIONS begins.....

The relation (CONTROL_AGENCY) was SYNTHESIZED and MINIMIZED as follows:

Original Relation is decomposed to :

(CALLSIGN : CONTROL_AGENCY, PRIMARY_FREQUENCY,
SECONDARY_FREQUENCY)

(CONTROL_AGENCY : CONTROL_POINT)

Checking for LOSSLESS JOIN begins....

Decomposition is LOSSLESS

The relations are SYNTHESIZED,
FD-PRESERVING, LOSSLESS, and MINIMAL relations

Now, ASSIGN the relation name for new relation(s).

New Decomposed Relations:
(CALLSIGN : CONTROL_AGENCY, PRIMARY_FREQUENCY,
SECONDARY_FREQUENCY)

Enter A new name for the relation above ==>

New Decomposed Relations:
(CONTROL_AGENCY : CONTROL_POINT)

Enter A new name for the relation above ==>

FDs after Normalization

1. CALLSIGN ---> CONTROL_AGENCY PRIMARY_FREQUENCY
SECONDARY_FREQUENCY
2. CONTROL_AGENCY ---> CONTROL_POINT

ENTERING FD FOR THE RELATION: AIR_TASKING_ORDER

AIR_TASKING_ORDER (ATO_START, ATO_STOP, AIR_TASKING_CODE)

ENTERING FD FOR THE RELATION: ROUTE

ROUTE (MISSION_NUMBER, POINT_NUMBER, CONTROL_POINT_TYPE, LOCATION,
ARRIVAL_TIME)

ENTERING FD FOR THE RELATION: RIO_LOGS

RIO_LOGS (MISSION_NUMBER, ACTUAL_TIME_OF_ARRIVAL,
ACTUAL_TIME_OF_RETURN)

ENTERING FD FOR THE RELATION: RECEIVING_AIRCRAFT

RECEIVING_AIRCRAFT (MISSION_NUMBER, A/C_CALLSIGN,
NUMBER_OF_AIRCRAFT, AIRCRAFT_TYPE, AMOUNT_OF_FUEL,
FUEL_REQUIREMENTS, REFUELING_TIME)

Candidate keys=

- 1 MISSION_NUMBER A/C_CALLSIGN

All Fd's entered for this relation

1: MISSION_NUMBER A/C_CALLSIGN ---> NUMBER_OF_AIRCRAFT
AIRCRAFT_TYPE AMOUNT_OF_FUEL REFUELING_TIME

2: NUMBER_OF_AIRCRAFT AMOUNT_OF_FUEL ---> FUEL_REQUIREMENTS

RESULT OF CHECKING NORMAL FORMS FOR RELATION
(RECEIVING_AIRCRAFT)

NOTATION: Y : SATISFACTORY N : NOT SATISFACTORY

FD no. BCNF 3NF

1	Y	Y
2	N	N

Removing the EXTRANEIOUS ATTRIBUTES begins.....

No extraneous attribute found

SEARCHING for REDUNDANT FDs begins.....

NO redundant FD found.

CONSTRUCTION OF RELATIONS begins.....

The relation (RECEIVING_AIRCRAFT) was SYNTHESIZED and MINIMIZED as follows:

Original Relation is decomposed to :

(MISSION_NUMBER, A/C_CALLSIGN : NUMBER_OF_AIRCRAFT, AIRCRAFT_TYPE,
AMOUNT_OF_FUEL, REFUELING_TIME)

(NUMBER_OF_AIRCRAFT, AMOUNT_OF_FUEL : FUEL_REQUIREMENTS)

Checking for LOSSLESS JOIN begins....

Decomposition is LOSSLESS

The relations are SYNTHESIZED,

FD-PRESERVING, LOSSLESS, and MINIMAL relations

Now, ASSIGN the relation name for new relation(s).

New Decomposed Relations:

(MISSION_NUMBER, A/C_CALLSIGN : NUMBER_OF_AIRCRAFT, AIRCRAFT_TYPE,
AMOUNT_OF_FUEL, REFUELING_TIME)

Enter A new name for the relation above ==>

New Decomposed Relations:

(NUMBER_OF_AIRCRAFT, AMOUNT_OF_FUEL : FUEL_REQUIREMENTS)

Enter A new name for the relation above ==>

FDs after Normalization

1. MISSION_NUMBER A/C_CALLSIGN ---> NUMBER_OF_AIRCRAFT
AIRCRAFT_TYPE AMOUNT_OF_FUEL REFUELING_TIME
2. NUMBER_OF_AIRCRAFT AMOUNT_OF_FUEL ---> FUEL_REQUIREMENTS

ENTERING FD FOR THE RELATION: **BATTLE_DAMAGE_ASSESSMENT**

BATTLE_DAMAGE_ASSESSMENT (LOCATION, TIME-ON-TARGET,
TIME-OFF-TARGET, PERCENT_ORDANANCE_ON_TARGET,
PERCENT_TARGET_DESTROYED, BDA_COMMENT, UNIT_SUPPORTED)

ENTERING FD FOR THE RELATION: **MISSION_LOCATION**

MISSION_LOCATION (MISSION_NUMBER, A/C_CALLSIGN, REQUEST_NUMBER,
LOCATION_TYPE, LOCATION, ALTITUDE, MISSION_COMMENT)

Candidate keys=

- 1 MISSION_NUMBER A/C_CALLSIGN REQUEST_NUMBER

All Fd's entered for this relation

- 1: REQUEST_NUMBER ---> LOCATION_TYPE LOCATION
- 2: MISSION_NUMBER A/C_CALLSIGN REQUEST_NUMBER ---> ALTITUDE
MISSION_COMMENT

RESULT OF CHECKING NORMAL FORMS FOR RELATION (MISSION_LOCATION)

NOTATION: Y : SATISFACTORY N : NOT SATISFACTORY
FD no. BCNF 3NF

1	N	N
2	Y	Y

Removing the EXTRANEIOUS ATTRIBUTES begins.....

No extraneous attribute found

SEARCHING for REDUNDANT FDs begins.....

NO redundant FD found.

CONSTRUCTION OF RELATIONS begins.....

The relation (MISSION_LOCATION) was SYNTHESIZED and MINIMIZED as follows:
Original Relation is decomposed to :
(REQUEST_NUMBER : LOCATION_TYPE, LOCATION)
(MISSION_NUMBER, A/C_CALLSIGN, REQUEST_NUMBER : ALTITUDE,
MISSION_COMMENT)
Checking for LOSSLESS JOIN begins....

Decomposition is LOSSLESS
The relations are SYNTHESIZED,
FD-PRESERVING, LOSSLESS, and MINIMAL relations

Now, ASSIGN the relation name for new relation(s).

New Decomposed Relations:

(REQUEST_NUMBER : LOCATION_TYPE, LOCATION)

Enter A new name for the relation above ==>

New Decomposed Relations:

(MISSION_NUMBER, A/C_CALLSIGN, REQUEST_NUMBER : ALTITUDE,
MISSION_COMMENT)

Enter A new name for the relation above ==>

FDs after Normalization

1. REQUEST_NUMBER --> LOCATION_TYPE LOCATION
2. MISSION_NUMBER A/C_CALLSIGN REQUEST_NUMBER --> ALTITUDE
MISSION_COMMENT

ENTERING FD FOR THE RELATION: MISSION

MISSION (MISSION_NUMBER, A/C_CALLSIGN, REQUEST_NUMBER,
NUMBER_OF_AIRCRAFT, AIRCRAFT_TYPE, MISSION_TYPE, ALERT_STATUS,
PRIMARY_CONFIGURATION_CODE, SECONDARY_CONFIGURATION_CODE,
IFF/SIF_CODES, EST_TIME_AIRBORNE, EST_TIME_OF_RETURN)

Candidate keys=

- 1 MISSION_NUMBER A/C_CALLSIGN REQUEST_NUMBER

All Fd's entered for this relation

1: MISSION_NUMBER A/C_CALLSIGN --> NUMBER_OF_AIRCRAFT
AIRCRAFT_TYPE MISSION_TYPE ALERT_STATUS
PRIMARY_CONFIGURATION_CODE SECONDARY_CONFIGURATION_CODE
IFF/SIF_CODES

- 2: A/C_CALLSIGN --> NUMBER_OF_AIRCRAFT AIRCRAFT_TYPE

3: MISSION_NUMBER ---> MISSION_TYPE

RESULT OF CHECKING NORMAL FORMS FOR RELATION (MISSION)
NOTATION: Y : SATISFACTORY N : NOT SATISFACTORY
FD no. BCNF 3NF

1	N	N
2	N	N
3	N	N

Removing the EXTRANEIOUS ATTRIBUTES begins.....

Extraneous attribute(s) found

*** Before Removing Extraneous Attributes: ***

1: MISSION_NUMBER A/C_CALLSIGN ---> NUMBER_OF_AIRCRAFT
AIRCRAFT_TYPE MISSION_TYPE ALERT_STATUS
PRIMARY_CONFIGURATION_CODE SECONDARY_CONFIGURATION_CODE
IFF/SIF_CODES EST_TIME_AIRBORNE EST_TIME_OF_RETURN

2: A/C_CALLSIGN ---> NUMBER_OF_AIRCRAFT AIRCRAFT_TYPE

3: MISSION_NUMBER ---> MISSION_TYPE

*** After Removing Extraneous Attributes: ***

1: MISSION_NUMBER A/C_CALLSIGN ---> ALERT_STATUS
PRIMARY_CONFIGURATION_CODE SECONDARY_CONFIGURATION_CODE
IFF/SIF_CODES EST_TIME_AIRBORNE EST_TIME_OF_RETURN

2: A/C_CALLSIGN ---> NUMBER_OF_AIRCRAFT AIRCRAFT_TYPE

3: MISSION_NUMBER ---> MISSION_TYPE

SEARCHING for REDUNDANT FDs begins.....

NO redundant FD found.

CONSTRUCTION OF RELATIONS begins.....

The relation (MISSION) was SYNTHESIZED and MINIMIZED as follows:

Original Relation is decomposed to :

(MISSION_NUMBER, A/C_CALLSIGN, REQUEST_NUMBER)

(MISSION_NUMBER, A/C_CALLSIGN : ALERT_STATUS,
PRIMARY_CONFIGURATION_CODE, SECONDARY_CONFIGURATION_CODE,
IFF/SIF_CODES, EST_TIME_AIRBORNE, EST_TIME_OF_RETURN)

(A/C_CALLSIGN : NUMBER_OF_AIRCRAFT, AIRCRAFT_TYPE)

(MISSION_NUMBER : MISSION_TYPE)

Checking for LOSSLESS JOIN begins....

Decomposition is LOSSLESS

The relations are SYNTHESIZED,
FD-PRESERVING, LOSSLESS, and MINIMAL relations

Now, ASSIGN the relation name for new relation(s).

New Decomposed Relations:

(MISSION_NUMBER, A/C_CALLSIGN, REQUEST_NUMBER)

Enter A new name for the relation above ==>

New Decomposed Relations:

(MISSION_NUMBER, A/C_CALLSIGN : ALERT_STATUS,
PRIMARY_CONFIGURATION_CODE, SECONDARY_CONFIGURATION_CODE,
IFF/SIF_CODES, EST_TIME_AIRBORNE, EST_TIME_OF_RETURN)

Enter A new name for the relation above ==>

New Decomposed Relations:

(A/C_CALLSIGN : NUMBER_OF_AIRCRAFT, AIRCRAFT_TYPE)

Enter A new name for the relation above ==>

New Decomposed Relations:

(MISSION_NUMBER : MISSION_TYPE)

Enter A new name for the relation above ==>

FDs after Normalization

1. MISSION_NUMBER A/C_CALLSIGN ---> ALERT_STATUS
PRIMARY_CONFIGURATION_CODE SECONDARY_CONFIGURATION_CODE
IFF/SIF_CODES EST_TIME_AIRBORNE EST_TIME_OF_RETURN
2. A/C_CALLSIGN ---> NUMBER_OF_AIRCRAFT AIRCRAFT_TYPE
3. MISSION_NUMBER ---> MISSION_TYPE

ENTERING FD FOR THE RELATION: TARGET_LOCATION

TARGET_LOCATION (TARGET_IDENTIFIER, MISSION_NUMBER, A/C_CALLSIGN,
REQUEST_NUMBER, TIME-ON-TARGET, TIME-OFF-TARGET, TARGET_TYPE,
LOCATION, TARGET_COMMENTS)

Candidate keys=

- 1 TARGET_IDENTIFIER MISSION_NUMBER A/C_CALLSIGN REQUEST_NUMBER

All Fd's entered for this relation

- 1: TARGET_IDENTIFIER ---> TIME-ON-TARGET TIME-OFF-TARGET TARGET_TYPE
LOCATION TARGET_COMMENTS

RESULT OF CHECKING NORMAL FORMS FOR RELATION (TARGET_LOCATION)

NOTATION: Y : SATISFACTORY N : NOT SATISFACTORY
FD no. BCNF 3NF

1 N N

Removing the EXTRANEIOUS ATTRIBUTES begins.....

No extraneous attribute found

SEARCHING for REDUNDANT FDs begins.....

NO redundant FD found.

CONSTRUCTION OF RELATIONS begins.....

The relation (TARGET_LOCATION) was SYNTHESIZED and MINIMIZED as follows:

Original Relation is decomposed to :

(TARGET_IDENTIFIER, MISSION_NUMBER, A/C_CALLSIGN, REQUEST_NUMBER)

(TARGET_IDENTIFIER : TIME-ON-TARGET, TIME-OFF-TARGET, TARGET_TYPE,
LOCATION, TARGET_COMMENTS)

Checking for LOSSLESS JOIN begins....

Decomposition is LOSSLESS

The relations are SYNTHESIZED,

FD-PRESERVING, LOSSLESS, and MINIMAL relations

Now, ASSIGN the relation name for new relation(s).

New Decomposed Relations:

(TARGET_IDENTIFIER, MISSION_NUMBER, A/C_CALLSIGN, REQUEST_NUMBER)

Enter A new name for the relation above ==>

New Decomposed Relations:

(TARGET_IDENTIFIER : TIME-ON-TARGET, TIME-OFF-TARGET, TARGET_TYPE,
LOCATION, TARGET_COMMENTS)

Enter A new name for the relation above ==>

FDs after Normalization

1. TARGET_IDENTIFIER ---> TIME-ON-TARGET TIME-OFF-TARGET TARGET_TYPE
LOCATION TARGET_COMMENTS

ENTERING FD FOR THE RELATION: IMMEDIATE_REQUESTS

IMMEDIATE_REQUESTS (IMMEDIATE_AIR_REQUEST_NUMBER, UNIT_SUPPORTED)

Candidate keys=

1 IMMEDIATE_AIR_REQUEST_NUMBER

All Fd's entered for this relation

1: IMMEDIATE_AIR_REQUEST_NUMBER ---> UNIT_SUPPORTED

RESULT OF CHECKING NORMAL FORMS FOR RELATION
(IMMEDIATE_REQUESTS)

NOTATION: Y : SATISFACTORY N : NOT SATISFACTORY

FD no. BCNF 3NF

1 Y Y

Removing the EXTRANEIOUS ATTRIBUTES begins.....

No extraneous attribute found

SEARCHING for REDUNDANT FDs begins.....

NO redundant FD found.

FDs after Normalization

1. IMMEDIATE_AIR_REQUEST_NUMBER ---> UNIT_SUPPORTED

ENTERING FD FOR THE RELATION: RECONNAISSANCE

RECONNAISSANCE (REQUEST_NUMBER, PRIORITY, MISSION_START,
MISSION_STOP, LATEST_TIME_INFO_OF_VALUE, MISSION_TYPE,
COVERAGE_TYPE)

Candidate keys=

1 REQUEST_NUMBER

All Fd's entered for this relation

1: REQUEST_NUMBER ---> PRIORITY MISSION_START MISSION_STOP
LATEST_TIME_INFO_OF_VALUE MISSION_TYPE COVERAGE_TYPE

RESULT OF CHECKING NORMAL FORMS FOR RELATION (RECONNAISSANCE)

NOTATION: Y : SATISFACTORY N : NOT SATISFACTORY

FD no. BCNF 3NF

1 Y Y

Removing the EXTRANEIOUS ATTRIBUTES begins.....

No extraneous attribute found

SEARCHING for REDUNDANT FDs begins.....

NO redundant FD found.

FDs after Normalization

1. REQUEST_NUMBER ---> PRIORITY MISSION_START MISSION_STOP
LATEST_TIME_INFO_OF_VALUE MISSION_TYPE COVERAGE_TYPE

ENTERING FD FOR THE RELATION: RECON_TARGET

RECON_TARGET (LOCATION, TARGET_LENGTH, TARGET_WIDTH)

Candidate keys=

1 LOCATION

All Fd's entered for this relation

1: LOCATION ---> TARGET_LENGTH TARGET_WIDTH

RESULT OF CHECKING NORMAL FORMS FOR RELATION (RECON_TARGET)

NOTATION: Y : SATISFACTORY N : NOT SATISFACTORY

FD no. BCNF 3NF

1 Y Y

Removing the EXTRANEIOUS ATTRIBUTES begins.....

No extraneous attribute found

SEARCHING for REDUNDANT FDs begins.....

NO redundant FD found.

FDs after Normalization

1. LOCATION ---> TARGET_LENGTH TARGET_WIDTH

ENTERING FD FOR THE RELATION: COMPRISES

COMPRISES (ATO_START, ATO_STOP, AIR_TASKING_CODE, MISSION_NUMBER, A/C_CALLSIGN)

ENTERING FD FOR THE RELATION: ASSESSES

ASSESSES (TARGET_IDENTIFIER, LOCATION, TIME-ON-TARGET, TIME-OFF-TARGET)

Candidate keys=

1 TARGET_IDENTIFIER TIME-ON-TARGET TIME-OFF-TARGET

All Fd's entered for this relation

1: TARGET_IDENTIFIER ---> LOCATION

RESULT OF CHECKING NORMAL FORMS FOR RELATION (ASSESSES)
NOTATION: Y : SATISFACTORY N : NOT SATISFACTORY
FD no. BCNF 3NF

1 N N

Removing the EXTRANEIOUS ATTRIBUTES begins.....

No extraneous attribute found

SEARCHING for REDUNDANT FDs begins.....

NO redundant FD found.

CONSTRUCTION OF RELATIONS begins.....

The relation (ASSESSES) was SYNTHESIZED and MINIMIZED as follows:

Original Relation is decomposed to :

(TARGET_IDENTIFIER, TIME-ON-TARGET, TIME-OFF-TARGET)

(TARGET_IDENTIFIER : LOCATION)

Checking for LOSSLESS JOIN begins....

Decomposition is LOSSLESS

The relations are SYNTHESIZED,

FD-PRESERVING, LOSSLESS, and MINIMAL relations

Now, ASSIGN the relation name for new relation(s).

New Decomposed Relations:

(TARGET_IDENTIFIER, TIME-ON-TARGET, TIME-OFF-TARGET)

Enter A new name for the relation above ==>

New Decomposed Relations:
(TARGET_IDENTIFIER : LOCATION)
Enter A new name for the relation above ==>

FDs after Normalization

1. TARGET_IDENTIFIER ---> LOCATION

ENTERING FD FOR THE RELATION: CONTROLS

CONTROLS (MISSION_NUMBER, A/C_CALLSIGN, CALLSIGN)

ENTERING FD FOR THE RELATION: REQUESTS

REQUESTS (IMMEDIATE_AIR_REQUEST_NUMBER, MISSION_NUMBER,
A/C_CALLSIGN)

ENTERING FD FOR THE RELATION: INTEREST_IN

INTEREST_IN (LOCATION, REQUEST_NUMBER)

Candidate keys=

1 REQUEST_NUMBER

All Fd's entered for this relation

1: REQUEST_NUMBER ---> LOCATION

RESULT OF CHECKING NORMAL FORMS FOR RELATION (INTEREST_IN)
NOTATION: Y : SATISFACTORY N : NOT SATISFACTORY
FD no. BCNF 3NF

1 Y Y

Removing the EXTRANEIOUS ATTRIBUTES begins.....

No extraneous attribute found

SEARCHING for REDUNDANT FDs begins.....

NO redundant FD found.

FDs after Normalization

1. REQUEST_NUMBER ---> LOCATION

ENTERING FD FOR THE RELATION: MAY_DESIGNATE

MAY_DESIGNATE (A/C_CALLSIGN, MISSION_NUMBER, POINT_NUMBER)

ENTERING FD FOR THE RELATION: UPDATES

UPDATES (ATO_START, ATO_STOP, AIR_TASKING_CODE, MISSION_NUMBER)

ENTERING FD FOR THE RELATION: REFUELS

REFUELS (MISSION_NUMBER, A/C_CALLSIGN, REQUEST_NUMBER)

Candidate keys=

1 A/C_CALLSIGN REQUEST_NUMBER

All Fd's entered for this relation

1: A/C_CALLSIGN REQUEST_NUMBER ---> MISSION_NUMBER

RESULT OF CHECKING NORMAL FORMS FOR RELATION (REFUELS)

NOTATION: Y : SATISFACTORY N : NOT SATISFACTORY

FD no. BCNF 3NF

1 Y Y

Removing the EXTRANEIOUS ATTRIBUTES begins.....

No extraneous attribute found

SEARCHING for REDUNDANT FDs begins.....

NO redundant FD found.

FDs after Normalization

1. A/C_CALLSIGN REQUEST_NUMBER ---> MISSION_NUMBER

Normalizer Functional Dependencies Summary

ASSESSSES FDs

TARGET_IDENTIFIER

--->

LOCATION

CONTROLS FDs

CALLSIGN

--->

CONTROL_AGENCY

PRIMARY_FREQUENCY

SECONDARY_FREQUENCY

CONTROL_AGENCY

--->

CONTROL_POINT

IMMEDIATE FDs

IMMEDIATE_AIR_REQUEST_NUMBER

--->

UNIT_SUPPORTED

INTEREST FDs

REQUEST_NUMBER

--->

LOCATION

MISSION FDs

REQUEST_NUMBER

--->

LOCATION_TYPE

LOCATION

MISSION_NUMBER
A/C_CALLSIGN
REQUEST_NUMBER
--->
ALTITUDE
MISSION_COMMENT

MSN FDs

MISSION_NUMBER
A/C_CALLSIGN
--->
ALERT_STATUS
PRIMARY_CONFIGURATION_CODE
SECONDARY_CONFIGURATION_CODE
IFF/SIF_CODES

A/C_CALLSIGN
--->
NUMBER_OF_AIRCRAFT
AIRCRAFT_TYPE

MISSION_NUMBER
--->
MISSION_TYPE

RECEIVING FDs

MISSION_NUMBER
A/C_CALLSIGN
--->
NUMBER_OF_AIRCRAFT
AIRCRAFT_TYPE
AMOUNT_OF_FUEL
REFUELING_TIME

NUMBER_OF_AIRCRAFT
AMOUNT_OF_FUEL
--->
FUEL_REQUIREMENTS

RECON FDs

REQUEST_NUMBER
--->
PRIORITY
MISSION_START
MISSION_STOP
LATEST_TIME_INFO_OF_VALUE
MISSION_TYPE
COVERAGE_TYPE

RECONTGT FDs

LOCATION
--->
TARGET_LENGTH
TARGET_WIDTH

REFUELS FDs

A/C_CALLSIGN
REQUEST_NUMBER
--->
MISSION_NUMBER

TARGET FDs

TARGET_IDENTIFIER
--->
TIME-ON-TARGET
TIME-OFF-TARGET
TARGET_TYPE
LOCATION
TARGET_COMMENTS

APPENDIX G: NORMALIZED RELATIONAL SCHEMA

AIR_TASKING_ORDER (*ato_start*, *ato_stop*, *air_tasking_code* :)

ROUTE (*mission_number*, *point_number* : *control_point_type*, *location*, *arrival_time*)

RIO_LOGS (*mission_number* : *actual_time_of_arrival*, *actual_time_of_return*)

BATTLE_DAMAGE_ASSESSMENT (*location*, *time-on-target*, *time-off-target* :
percent_orinance_on_target, *percent_target_destroyed*, *bda_comment*, *unit_supported*)

IMMEDIATE_REQUESTS (*immediate_air_request_number* : *unit_supported*)

RECON_TARGET (*location* : *target_length*, *target_width*)

COMPRISES (*ato_start*, *ato_stop*, *air_tasking_code*, *mission_number*, *a/c_callsign* :)

CONTROLS (*mission_number*, *a/c_callsign*, *callsign* :)

REQUESTS (*immediate_air_request_number*, *mission_number*, *a/c_callsign* :)

INTEREST_IN (*request_number* : *location*)

MAY_DESIGNATE (*a/c_callsign*, *mission_number*, *point_number* :)

UPDATES (*ato_start*, *ato_stop*, *air_tasking_code*, *mission_number* :)

REFUELS (*a/c_callsign*, *request_number* : *mission_number*)

COMMUNICATION_DATA (*callsign* : *control_agency*, *primary_frequency*,
secondary_frequency)

REPORT-IN_POINTS (*control_agency* : *control_point*)

RECEIVING_AIRCRAFT (*mission_number*, *a/c_callsign* : *number_of_aircraft*, *aircraft_type*,
amount_of_fuel, *refueling_time*)

FUEL_REQUIREMENTS (*number_of_aircraft*, *amount_of_fuel* : *fuel_requirements*)

REQ_LOCATION (*request_number* : location_type, location)

REQ_STATUS (*mission_number*, *a/c_callsign*, *request_number* : altitude, mission_comment)

MSN_STATUS (*mission_number*, *a/c_callsign*, *request_number* :)

A/C_STATUS (*mission_number*, *a/c_callsign* : alert_status, primary_configuration_code, secondary_configuration_code, iff/sif_codes, est_time_airborne, est_time_of_return)

A/C_WEAPONS (*a/c_callsign* : number_of_aircraft, aircraft_type)

MSN_TYPE (*mission_number* : mission_type)

TGT_MSN (*target_identifier*, *mission_number*, *a/c_callsign*, *request_number* :)

TGT_DATA (*target_identifier* : time-on-target, time-off-target, target_type, location, target_comments)

TGT-TIME (*target_identifier*, time-on-target, time-off-target :)

TGT-ID_LOCN (*target_identifier* : location)

RECON_REQUEST (*request_number* : priority, mission_start, mission_stop, latest_time_info_of_value, mission_type, coverage_type)

Normalized Relational Schema File Format

AIR_TASKING_ORDER 3 3

ATO_START	C,7
ATO_STOP	C,7
AIR_TASKING_CODE	C,43

ROUTE 5 2

MISSION_NUMBER	C,8
POINT_NUMBER	N,2
CONTROL_POINT_TYPE	C,3
LOCATION	C,20
ARRIVAL_TIME	C,7

RIO_LOGS 3 1

MISSION_NUMBER	C,8
ACTUAL_TIME_OF_ARRIVAL	N,4
ACTUAL_TIME_OF_RETURN	N,4

BATTLE_DAMAGE_ASSESSMENT 7 3

LOCATION	C,20
TIME-ON-TARGET	C,7
TIME-OFF-TARGET	C,7
PERCENT_ORDANANCE_ON_TARGET	N,2
PERCENT_TARGET_DESTROYED	N,2
BDA_COMMENT	C,30
UNIT_SUPPORTED	C,9

IMMEDIATE_REQUESTS 2 1

IMMEDIATE_AIR_REQUEST_NUMBER	C,5
UNIT_SUPPORTED	C,9

RECON_TARGET 3 1

LOCATION	C,20
TARGET_LENGTH	C,7
TARGET_WIDTH	C,7

COMPRISES 5 5

ATO_START	C,7
ATO_STOP	C,7
AIR_TASKING_CODE	C,43
MISSION_NUMBER	C,8
A/C_CALLSIGN	C,12

CONTROLS 3 3	
MISSION_NUMBER	C,8
A/C_CALLSIGN	C,12
CALLSIGN	C,15
REQUESTS 3 3	
IMMEDIATE_AIR_REQUEST_NUMBER	C,5
MISSION_NUMBER	C,8
A/C_CALLSIGN	C,12
INTEREST_IN 2 1	
REQUEST_NUMBER	C,6
LOCATION	C,20
MAY_DESIGNATE 3 3	
A/C_CALLSIGN	C,12
MISSION_NUMBER	C,8
POINT_NUMBER	N,2
UPDATES 4 4	
ATO_START	C,7
ATO_STOP	C,7
AIR_TASKING_CODE	C,43
MISSION_NUMBER	C,8
REFUELS 3 2	
A/C_CALLSIGN	C,12
REQUEST_NUMBER	C,6
MISSION_NUMBER	C,8
COMMUNICATION_DATA 4 1	
CALLSIGN	C,15
CONTROL_AGENCY	C,4
PRIMARY_FREQUENCY	C,8
SECONDARY_FREQUENCY	C,8
REPORT-IN_POINTS 2 1	
CONTROL_AGENCY	C,4
CONTROL_POINT	C,20

RECEIVING_AIRCRAFT 6 2	
MISSION_NUMBER	C,8
A/C_CALLSIGN	C,12
NUMBER_OF_AIRCRAFT	N,2
AIRCRAFT_TYPE	C,6
AMOUNT_OF_FUEL	N,4
REFUELING_TIME	C,7
FUEL_REQUIREMENTS 3 2	
NUMBER_OF_AIRCRAFT	N,2
AMOUNT_OF_FUEL	N,4
FUEL_REQUIREMENTS	N,4
REQ_LOCATION 3 1	
REQUEST_NUMBER	C,6
LOCATION_TYPE	C,6
LOCATION	C,20
REQ_STATUS 5 3	
MISSION_NUMBER	C,8
A/C_CALLSIGN	C,12
REQUEST_NUMBER	C,6
ALTITUDE	C,5
MISSION_COMMENT	C,22
MSN_STATUS 3 3	
MISSION_NUMBER	C,8
A/C_CALLSIGN	C,12
REQUEST_NUMBER	C,6
A/C_STATUS 8 2	
MISSION_NUMBER	C,8
A/C_CALLSIGN	C,12
ALERT_STATUS	C,3
PRIMARY_CONFIGURATION_CODE	C,5
SECONDARY_CONFIGURATION_CODE	C,5
IFF/SIF_CODES	C,5
EST_TIME_AIRBORNE	N,4
EST_TIME_OF_RETURN	N,4

A/C_WEAPONS 3 1	
A/C_CALLSIGN	C,12
NUMBER_OF_AIRCRAFT	N,2
AIRCRAFT_TYPE	C,6
MSN_TYPE 2 1	
MISSION_NUMBER	C,8
MISSION_TYPE	C,5
TGT_MSN 4 4	
TARGET_IDENTIFIER	C,20
MISSION_NUMBER	C,8
A/C_CALLSIGN	C,12
REQUEST_NUMBER	C,6
TGT_DATA 6 1	
TARGET_IDENTIFIER	C,20
TIME-ON-TARGET	C,7
TIME-OFF-TARGET	C,7
TARGET_TYPE	C,6
LOCATION	C,20
TARGET_COMMENTS	C,35
TGT-TIME 3 3	
TARGET_IDENTIFIER	C,20
TIME-ON-TARGET	C,7
TIME-OFF-TARGET	C,7
TGT-ID_LOCN 2 1	
TARGET_IDENTIFIER	C,20
LOCATION	C,20
RECON_REQUEST 7 1	
REQUEST_NUMBER	C,6
PRIORITY	C,1
MISSION_START	C,7
MISSION_STOP	C,7
LATEST_TIME_INFO_OF_VALUE	C,11
MISSION_TYPE	C,5
COVERAGE_TYPE	C,7

APPENDIX H: dBASE IV REPORTS

Retrieving information in dBASE IV is accomplished through queries. Queries generate views of the database to meet the user and application requirements. Views are *virtual databases*, logical, not physical structures. Views allow:

- data to be seen in different ways without physical duplication
- manipulation of data without changing original database
- database security
- users to be shielded from changes in the physical database

The query generated views are used by user for "on the fly" manipulation of data, or by the application for report and form generation. Tables are linked to one another in the DASC database through queries, and views, forms, and reports developed using these multiple tables.

The following examples show the capabilities of the DASC application:

- Report-In/Out Log view that links multiple tables
- BDA update form for data insertion of BDA data
- Immediate Air Support Report that lists immediate air support requests received, supported unit, mission assignment and BDA
- Report-In/Out Log Report

REPORT-IN/OUT LOG VIEW

Records Organize Fields Go To Exit

MSNNO	C_S	NO	ACTYPE	PRICONFIG	SECCONFIG	ETA	ATA	ETR	ATR	CALL
30F0001	KILLER 1	2	F/A-18	6MK82	AC01	1200	1300	1330	1345	RED
30F0003	NIGHT HAWK 3	1	RF-4			1430	1430	1545	1530	BLAC
30F0005	KILLER 5	2	F/A-18	6MK82	AC01	1200				BLAC
30F0007	RAIDER 7	1	KC-130			1130	1245	1500	1530	BLAC
30H0002	GHOST 2	6	CH-46			0900	845	1100	1000	RED
30H0004	SCARFACE 4	2	UH-1N	AC01	AC02	0845	845	1015	1000	BLAC
23H0006	SCARFACE 6	2	AH-1W	AC01	AC02	1200	1300	1330	1415	BLAC

Browse ||F:\dbsample\RIOVIEW ||Rec 1/7 ||View ||ReadOnly|| Num

BDA UPDATE FORM (empty)

BDA UPDATE FORM

LOCN			
TOT		TFT	
ORD_ON_TGT	0	TGT_DEST	0
BDACMNT			
SUPPORTED			

BDA UPDATE FORM (complete)

BDA UPDATE FORM

LOCN		32SMV1234512345	
TOT 301300Z		TFT 301310Z	
ORD_ON_TGT	50	TGT_DEST	50
BDACMNT			
2 TANKS DESTROYED			
SUPPORTED		3/1	

IMMEDIATE AIR SUPPORT SUMMARY REPORT

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IMMEDIATE AIR SUPPORT SUMMARY =====

IMMEDIATE =====	SUPPORTED =====	MSNNO =====	BDA =====	BDA COMMENT =====
0-01	3/1	30F0001	50/50	2 TANKS DESTROYED
0-03	3/1	30H0006	90/90	DESTROYED VEHICLE

REPORT-IN/OUT LOG REPORT

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REPORT-IN/OUT LOG =====

SNNO =====	C_S =====	NO =====	ACTYPE =====	ETR =====	ETA =====	ATA =====	ATR =====	CONTROL C/S =====
0F0001	KILLER 1	2	F/A-18	1330	1200	1300	1345	RED DOG
0F0003	NIGHT HAWK 3	1	RF-4	1545	1430	1430	1530	BLACKLIST
0F0005	KILLER 5	2	F/A-18	1200	1200	0	0	BLACKLIST
0F0007	RAIDER 7	1	KC-130	1500	1130	1245	1530	BLACKLIST
0H0002	GHOST 2	6	CH-46	1100	0900	845	1000	RED DOG
0H0004	SCARFACE 4	2	UH-1N	1015	0845	845	1000	BLACKLIST
0H0006	SCARFACE 6	2	AH-1W	1330	1200	1300	1415	BLACKLIST

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